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OBSERVATIONS ON *POLYPORUS LUCIDUS* LEYS. AND SOME OF ITS ALLIES FROM EUROPE AND NORTH AMERICA[1]

GEORGE F. ATKINSON

(WITH FIVE FIGURES AND PLATE XIX)

The close relationship between the fungus flora of Europe and North America has long been recognized. There are many species which are common to both countries. This in a large measure is due to the same general conditions which have long been recognized in explaining the similarity between the spermatophytic floras of the two countries, namely, the strong evidence presented by certain geologic periods that many centuries ago the two floras were contiguous in the arctic regions, at a time when the climate there was mild enough to permit the growth of those species and genera, contributing through their progeny the present representatives, which have survived the climatic and edaphic rigors to which they were subjected during the subsequent glaciation of the arctics, and the shifting glacial movement farther to the south. The fungus flora of a country bears a very close and important ecological relation to other plants, especially to the spermatophytic flora, whether as parasitic, humus-dwelling, or wood-destroying species. They are "camp followers" of the higher plants. Because of this symbiotic and metabiotic relation of the fungi to other plants, in a great measure their lodging and migration is coincident with that of their hosts. In the case of the forest fungi there are some interesting examples of tenacious adherence to specific hosts, or to descendant species which have become separated in the migratory movement from the parent

[1] Contribution from the Department of Botany, Cornell University, No. 130.

stock. There are also interesting examples of a shift from one host to a host of another related genus, instead of to a species of the same genus, where in the migration the specific hosts are not evenly distributed over the area of general migration from a given region. *Pleurotus ulmarius* Bull., while occurring on other frondose trees, is more common on the elm both in Europe and North America, although our native species of elm is different specifically from the European elm. *Annularia fenzlii* Schulz. was first collected in Hungary on *Tilia europaea* and does not seem to be common or widely distributed in other parts of Europe. It has been collected once at Ithaca, N. Y., on our native species of basswood, *Tilia americana*. *Fomes fraxineus* (Bull.) Fr. seems to be confined to the ash, occurring on the European ash in Europe and on our native species in the United States. *Fistulina hepatica* (Huds.) Fr. occurs in Europe especially on the oak, but sometimes on beech and chestnut. In North America it occurs most commonly on the chestnut, but is reported also on the oak, European species of oak not occurring naturally in this country. Many other similar examples might be enumerated. In a number of cases the fungus species seems to have undergone little or no change, although now separated for centuries on two different continents and subjected often to widely different environmental conditions. In other cases the North American representative of European species seems to have undergone a change, whether gradual or sudden we cannot say, so that it presents certain constant characters worthy often of specific separation, while resembling in a striking way the European species.

One of these interesting problems is presented by *Polyporus lucidus* Fr.[2] (*Boletus lucidus* Leys.[3]). My first acquaintance with what appears to be the typical form of *P. lucidus* in Europe was in the autumn of 1903, when I collected a specimen growing from the root of a dead frondose tree in the Bois de Boulogne, Paris. Two years later, while visiting M. E. BOUDIER at Montmorency, near Paris, he gave me a fresh young specimen which had been sent him from one of his numerous correspondents in France. It is a large and handsome fungus, varying considerably in size and form. The typical forms are stipitate, with a lateral pileus. In these forms

[2] Flora Halensis 300. 1783. [3] Syst. Myc. 1:353. 1821.

the stipe is usually quite fully developed before the formation of the pileus, the latter developing gradually as a lateral extension of the free end of the stipe and becoming dimidiate, reniform, or flabelliform, usually with an entire margin, but sometimes more or less

FIG. 1.—*Ganoderma pseudoboletum* (Jacq.) Murrill (*Polyporus "lucidum"* Leys.) (natural size), from France.

crenate or rarely somewhat lobed. Sometimes the pileus is nearly sessile, the stipe being reduced to a stout tubercle, especially when the plants grow directly on the side of a log. The plants occur singly or in clusters, and sometimes imbricated. One of the striking characters, which is also a peculiarity of a number of other species,

is the formation of a colored viscous substance on the surface of the stem and pileus which dries and hardens into a smooth, hard, thin, lustrous crust or "skin," which gives the plants a varnished appearance. In typical forms of *P. lucidus* this is a reddish chestnut, or *marron* color, varying to darker colors or even blackish in some forms of the species. The surface of the pileus is often marked by concentric rings and furrows, usually not very pronounced, and usually toward or on the margin where the rings are often close together. The surface is often radiately rugose. The pileus varies from 2–25^{cm} or more in diameter and 1–4^{cm} thick behind. The stipe varies greatly in length, and from 0.5–4^{cm} in diameter. The tubes are long and slender, brown within, the mouths circular, angular, white or yellowish, finally yellowish brown, with the dissepiments thin and acute. The trama or context of the pileus is pallid to brown, the portion next the tubes being darker brown, about the same color as the tubes, while it is paler to almost white next the varnished crust. The context of the stem is brown, with more or less distinct transverse concentric zones, which are also found to some extent in the pileus, and there is a distinct radiating fibrous structure extending into the pileus. The context is also soft and "punky."

Before the plant is mature, and while it is in different stages of development, the growing end of the stipe and the growing margin of the pileus are whitish, then changing to reddish yellow and finally chestnut as the varnishing becomes complete.[4] BULLIARD[5] and GILLET[6] figure young plants showing the lighter-colored margin. This condition is different from the yellowish unvarnished condition of the pileus of *P. curtisii* Berk.[7] from the southern United States, with which MURRILL[8] compared BULLIARD's and GILLET's figure.

The fact that the typical form of *P. lucidus* occurs in Europe on frondose trees lends additional interest to the most common form of this species in the United States, which occurs on the hemlock-

[4] See EDGERTON, C. W., The rate and period of growth of *Polyporus lucidus*. Torreya **7**:89–97. 1907.

[5] *Boletus obliquatus* Bulliard. Herb. de la France. *pl. 7, fig. A, pl. 459, figs. B, C.* 1880–1890?

[6] *Polyporus lucidus* Fr. Gillet. Champignons de la France 666.

[7] *Polyporus curtisii* Berkeley. Hook. Jour. Bot. **1**:101. 1849.

[8] Bull. Torr. Bot. Club **29**:604. 1902.

spruce (*Tsuga canadensis*). This form can be distinguished from the typical form on frondose trees in Europe only by the fact that it

FIG. 2.—*Ganoderma pseudoboletum* forma *monianum* Atkinson (×½), on dead spruce, Jura Mts., France.

grows on a conifer, the hemlock-spruce, rather than on frondose trees, and perhaps by its somewhat softer and perhaps slightly lighter-

colored context, and the longer persistence of the individuals of the European form, since this usually does not disintegrate so soon. But these characters vary in individual plants and seem to mark our form on the hemlock-spruce merely as a physiological or biological form of the European species, rather than as a distant species as it is regarded by MURRILL[9] (p. 606).

P. lucidus is rarely reported on conifers in Europe, though it probably is common enough in certain of the mountainous regions. KARSTEN[10] reports it on *Abies excelsa* in Finland. In 1905 I found it quite common in the Jura Mountains[11] near Pontarlier and Boujeailles, Province Doubs, France, on dead stumps and logs of the common fir (*sapin*) of that region. These plants, while showing great variation in form, do not depart in this respect from the typical form. The stem varies from lateral to central in some individuals. There is, however, a marked difference in color, the Jura specimens on the fir having the varnished surface darker in color than those which I have seen from frondose trees in Europe, but also darker than our form on the hemlock-spruce, the color being a dark mahogany red, finally becoming nearly black. The color of the context is brownish like that of the typical form. So far as I could observe, I could see no evidence that this form is perennial, nor have I seen perennial specimens of the typical form. I sent specimens of these plants collected on the fir in the Jura Mountains to M. E. BOUDIER, of Montmorency, and at the same time some of the American form collected on the hemlock-spruce. The latter he pronounced a typical form of *P. lucidus*, while the former he regarded merely as a black form of the same species, which he says grows in the Vosges and Jura in France and Germany. The spores are identical in structure and size in all the above-mentioned forms.

The form in the southern United States on roots, stumps, etc., of frondose trees, seems to be distinct enough to be regarded as a distinct species. BERKELEY so regarded it and described it as *P.*

[9] *Ganoderma tsugae* Murrill. The Polyporaceae of N. Am. I. The genus Ganoderma. Bull. Torr. Bot. Club **29**:599–608. 1902; N. Am. Flora **9**[2]:118. 1908.

[10] KARSTEN, P. A., Myc. Fenn. pars tertia, Basidiomycetes, in Bidrag till Kännedom af Finlands Natur Och Folk **25**:254. 1876.

[11] The collection and study of this material, with many other European fungi, was made possible because of a grant from the Botanical Society of America.

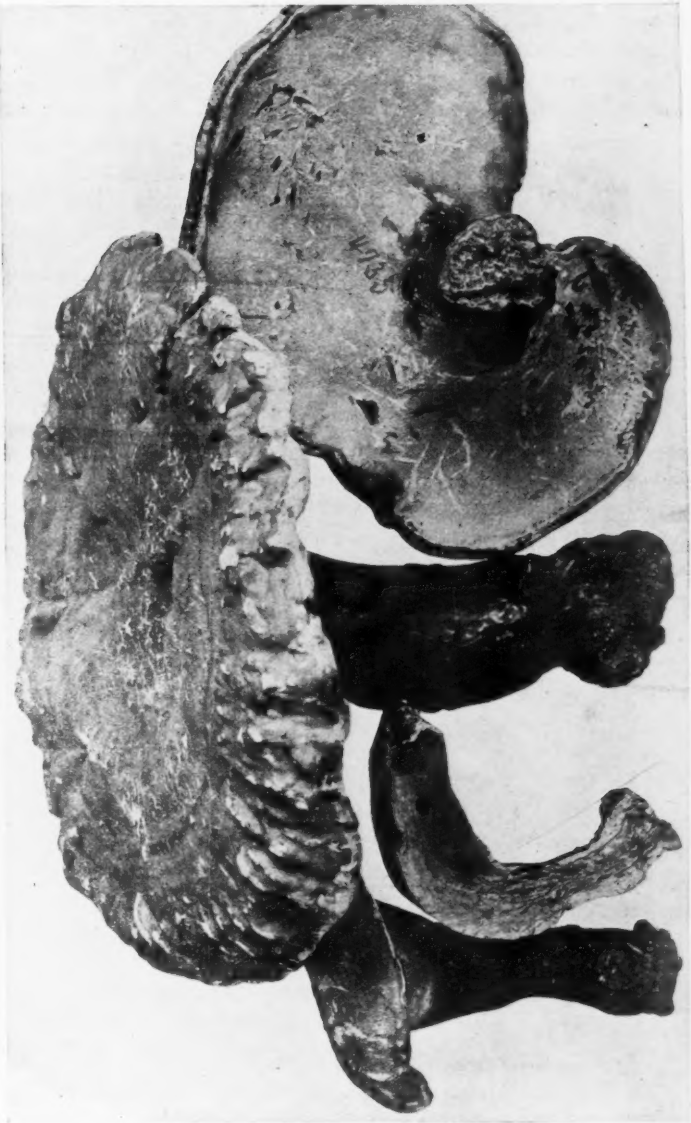

FIG. 3.—*Ganoderma curtisii* (Berk.) Murrill; central plant from Texas, others from North Carolina.

curtisii.[12] The general form of the plant is the same as that of *P. lucidus*, but the pileus is rarely and then only slightly varnished, and is yellowish in color, or with reddish-yellow spots and zones. The stem is exactly like that of *P. lucidus* and is varnished, reddish chestnut in color. In the extreme south forms with a central stem are more common, and then the pileus is more or less depressed in the center, as in *fig. 2*, which represents a specimen collected in Texas by A. M. FERGUSON. The surface is often zonate, faintly or strongly sulcate, and sometimes radiately rugose or corrugated toward the margin. While MURRILL first considered this as merely a geographical form[13] of *P. lucidus* (*Ganoderma pseudoboletus* Murr.), he now treats it as a distinct species[14] (*G. curtisii* [Berk.] Murr.).

Another form which has come under my observation was sent me by Mr. M. E. HARD, of Chillicothe, Ohio, who collected it from dead buried roots of oak, growing among *Datura stramonium*. These plants (*fig. 5*) resemble the typical European form in color and consistency. These individual specimens were not fully grown, and therefore the margin is lighter colored. The pileus as well as the stem is laccate or varnished. There are some differences in the spores which will be discussed below.

Another interesting form was received from E. R. LAKE, of Corvallis, Oregon, in January, 1905. It is a large stipitate plant with a lateral pileus, the pileus measuring 14^{cm} long by 12^{cm} broad and 5.5^{cm} thick. The pileus is tumid and covered with a thin crust, which is brittle, dark reddish brown, and laccate, similar to the crust of the stem. The context of the stem is also white and shows a fibrous structure which radiates out into the pileus. The tubes are slender, cinnamon brown, and $2–5^{cm}$ long. The plant was growing apparently on burnt ground from a root, probably of some conifer. In this specimen the varnished crust of the pileus extends over the under side of the margin and over the hymenophore for a distance of $0.5–1^{cm}$, and a new stratum of tubes 4^{mm} in length is deposited over the remaining portion of the hymenophore. In sections of the hymenophore this stratum tends to break away rather easily from its

[12] *Polyporus curtisii* Berk. Hook. Jour. Bot. 1:101. 1849.

[13] Bull. Torr. Bot. Club 29:602. 1902.

[14] N. Am. Flora 9^2:120. 1908.

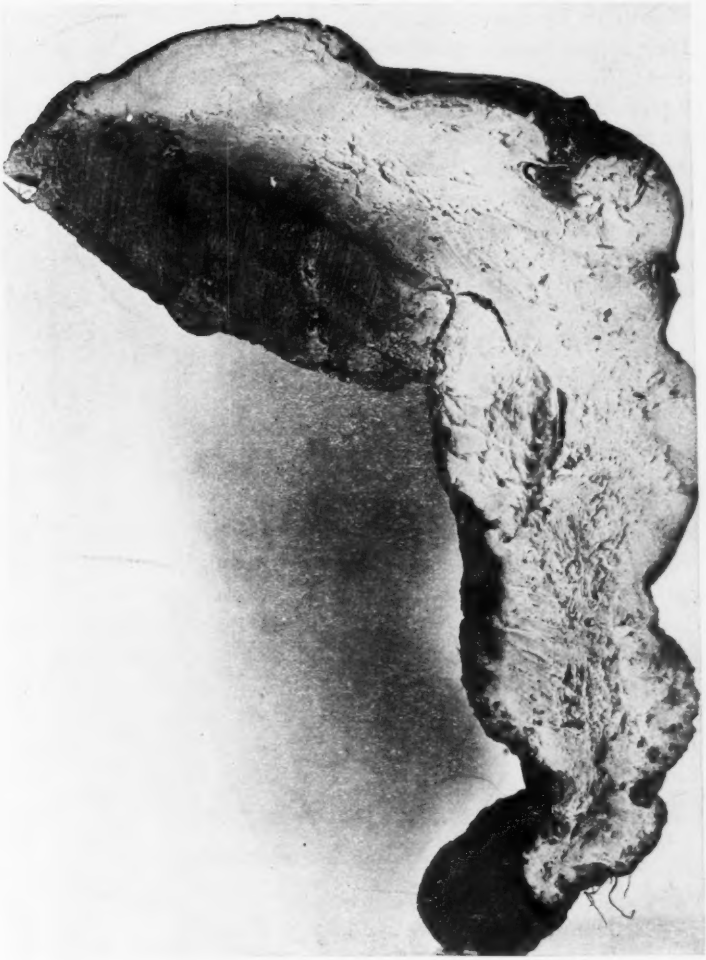

FIG. 4.—*Ganoderma oregonense* Murrill, from Corvallis, Oregon (natural size).

point of attachment with the older portion. There is also a faint stratification of the main portion of the hymenophore, but whether this is due to successive annual layers is doubtful, and can be deter-

mined only by observation of individual plants from year to year. They appear more likely to be the result of periodic variations in a single season's growth, like some of the similar strata in *Fomes fomentarius*. The plant has the appearance of being normally an annual, which under certain conditions may persist for a second season and develop a second depauperate layer of tubes; or this layer may be developed at the close of the first season, often some unfavorable condition inhibiting the growth for a longer period than usual. It appears to be specifically identical with *Ganoderma oregonense* Murrill,[15] recently described from Oregon as growing on a log of *Picea sitkensis*.

The spores of the species discussed in this paper present some very remarkable peculiarities in form and markings, which seem to have been misinterpreted by all those who have attempted to describe them up to the present time. During the past autumn and winter I have made a critical examination of the spores of the species mentioned above, and have not been able to confirm the descriptions thus far given. KARSTEN in 1889[16] says the spores are warty (sporerna äggrunda eller elliptiska, vörtiga, gulbrunaktiga). PATOUILLARD in 1887[17] describes and figures the spores of the genus Ganoderma as verrucose (verruqueuses) and cites *Ganoderma lucidum* as one of the typical species. Later[18] (p. 66) this is repeated where he places *Ganoderma lucidum* in the section of Ganoderma having verrucose spores (spores verruqueuses). SACCARDO[19] says that the spores of this species are slightly verrucose (forma typica sporis ovoides, leviter verrucosis), and BRESADOLA states that they are verrucose.[20] MURRILL in 1902[21] and again in 1908[22] describes them

[15] N. Am. Flora **9**[2]:119. 1908.

[16] Kritisk Ofversigt af Finl. Basidsv. 327. 1889.

[17] Les Hyménomycètes d'Europe 142. *pl. 3. fig. 21.* 1887.

[18] Le genre Ganoderma. Bull. Soc. Myc. France **5**:63–83. *pls. 10, 11.* 1889; see also PATOUILLARD, N., Essai taxonomique sur les familles et les genres des Hyménomycètes 105. *fig. 58, 3b.* 1900.

[19] Sylloge Fung. **6**:157. 1888.

[20] Hymenomycetes Hungarici Kmetiani. Atti Acad. Sci. III. **3**:73. 1897.

[21] Bull. Torr. Bot. Club **29**:601. 1902.

[22] N. Am. Flora **9**[2]:118. 1908.

as verrucose in several species (*Ganoderma tsugae* Murrill, *G. lucidum* [Leys.] Karsten, *G. curtisii* [Berk.] Murrill, and others).

In studying the spores of these species I have been surprised to find that they are not echinulate or roughened. The spore wall is *smooth*, that is, there are no elevated or projecting portions of the surface. But the spores have a very peculiar structure, which re-

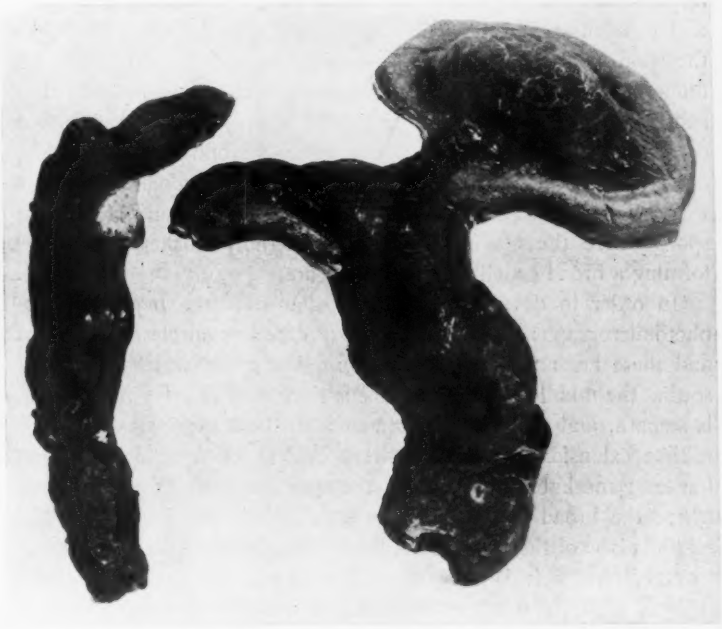

FIG. 5.—*Ganoderma subperforatum* Atkinson, from Ohio (natural size).

quires very careful examination to interpret properly, and sometimes the use of the oil immersion lens is necessary to resolve clearly the characteristic structure of the wall. On a first examination of the spores with the dry objective, they appear warty or roughened; but the appearance is so peculiar that I was not content with this definition and sought to determine more accurately the nature of the peculiar structure. When the upper or lower surface of the spore is in the focal plane, the wall of the spore presents the appearance of

being verrucose from the presence of numerous brownish or yellowish-brown points; but when one examines the wall at the middle focal plane, these colored dots are seen not to project beyond the outer surface of the wall, though both above and below the middle focal plane they do appear as echinulations. The structure seemed to be so puzzling that I was led to employ the oil immersion lens (Zeiss apochromatic homogeneous immersion lens, equivalent focus 1.5^{mm} and compensation ocular 6). This revealed the true structure of the spore wall. It is hyaline or nearly so, and is perforated with numerous slender rodlike extensions of a brown or yellowish-brown substance, which appear as if they might be projections of the colored content of the spore. These do not extend beyond the outer surface of the wall, and they radiate from the endospore through the hyaline wall. They are especially prominent at the smaller end of the oval spore where the hyaline wall is considerably thicker, sometimes forming a broad conelike cap to the spore.

In order to demonstrate this peculiar structure beyond doubt, photomicrographs were made of four different species and forms, and these are reproduced in *pl. 19*. The spores which were lying so that the middle plane was in focus show very clearly that the wall is smooth, and that it is perforated with these short, dark-colored, rodlike extensions. These are very evident all around the spore, but are remarkably prominent at the apex, especially in those spores where the broad conelike hyaline cap is still intact. Where the middle plane of the spore is not in the focal plane, the spores appear "warty," but this is only an optical illusion. This is especially striking in *pl. fig. 6*, where the middle plane of nearly all the spores was out of focus. For the species from which these photomicrographs were made the reader is referred to the description of figures. The fact that the spore wall is hyaline or subhyaline, and perforated with dark lines, gives such prominence to the latter that they are apt to be taken for warts or echinulations when the examination is hasty. The hyaline portion of the spore wall appears also to be of a less firm consistency than the colored perforations or lines, and if the spores dry at a certain age, perhaps before they are quite mature, the hyaline portion of the wall appears often to shrink or collapse somewhat, thus making the colored points stand out as echinulations,

but a careful examination with the oil immersion lens reveals their true structure.

Besides the markings of the spores of these species, there is another peculiarity which has been erroneously interpreted by those who have tried to describe them. This peculiarity relates to the form of the spore. PATOUILLARD[23] in 1889 describes them as truncate and emarginate at the base (tronquées et echancrées à la base) and in 1900[24] simply as truncate at the base. BRESADOLA[25] says the spores in *Ganoderma lucidum* are obovate, at length truncate at the base (sporae obovatae, demum basi truncatae). MURRILL[26] describes them in several species as follows: "Spores ovoid, obtuse at the summit, attenuate and truncate at the base." But a careful study of the spores shows that exactly the reverse is true. The base of the spore is the broadly rounded end, while the apex is the narrowed, "truncate" end. In *Ganoderma lucidum* (Leys.) Karsten from Europe, including the forms collected by myself on the fir in the Jura Mountains, in *G. tsugae* Murrill and *G. curtisii* (Berk.) Murrill, both from the United States, the spores are all similar and practically identical. They are ovate in form, and when they are lying so that they can be seen in side view, they are seen to be more or less inequilateral, that is, one side is more convex than the other. The place where the spore was attached to the sterigma is at the side of the broad rounded end opposite the convex side. Sometimes a minute angle can be seen here where the sterigma was attached. Boiling the spores in a weak solution of potassium hydrate brings out the entire structure more clearly, and at this point, where the sterigma was attached, the spore wall is very thin, there being a slender channel extending from the endospore almost through the epispore to the point where the sterigma was attached. The treatment with potash, however, is not necessary in order to demonstrate the characteristic structure of the spores described above in these species. An examination of the spores in the plate will show several in which the very thick wall at the apex is still intact and forms a broad conelike cap

[23] Bull. Soc. Bot. France **5**:66. 1889.

[24] Essai taxonomique sur les familles et les genres de Hyménomycètes 105. 1900.

[25] Hymenomycetes Hungarici Kmetiani. Atti Acad. Sci. III. **3**:73. 1897.

[26] Bull. Torr. Bot. Club **29**:601. 1902; N. Am. Flora **9**²:118, 120. 1908.

on the spore. As the spore matures and dries, this cap in most cases either collapses or breaks off, leaving a" truncate" or "emarginate" end.

The spores of *P. applanatus* of both Europe and the United States have exactly the same general structure as those of *Ganoderma lucidum* described above, as I shall explain in another paper.

The spores of *Ganoderma oregonense* Murrill have the same structure, but the wall is thinner and the structure is not quite so easy to make out. The form of the spores is also somewhat different, being more nearly elliptical in form, though some are obovate, and they are slightly larger. In the spores from Ganoderma received from Mr. HARD, mentioned above as growing on roots of an oak, the peculiarities in the structure of the wall described above for *G. lucidum* and some other species are not well developed, and are demonstrated with difficulty. After several examinations, even with the use of the oil immersion lens, I had nearly come to the conclusion that this species was an exception; but after boiling the spores in a weak solution of potassium hydrate, the brownish perforations of the wall were faintly visible. With some other differences in spore character this species seems to be different from the others. In order to present my interpretation of the different species employed in this study of specimens from Europe and the United States, I will add the following diagnoses.

GANODERMA PSEUDOBOLETUM (Jacq.) Murrill,[27] Bull. Torr. Bot. Club **29**:602. 1902.

Agaricus pseudoboletus Jacq. Flor. Austr. **1**:26–27. *pl. 41*. 1773.
Boletus rugosus Jacq. Flor. Austr. **2**:44. *pl. 169*. 1774.
Boletus lucidus Leys. Flora Halensis 300. 1783.
Boletus obliquatus Bull. Herb. France. *pl. 7*. 1780; *pl. 459*. 1790.
Polyporus lucidus Fries, Syst. Myc. **1**:353. 1821.
Polyporus laccatus Pers. Myc. Eur. **2**:54. 1825.

[27] In Jour. Myc. **9**:94. 1903, MURRILL uses the combination *Ganoderma flabelliforme* (Scop.) Murrill (*Boletus flabelliformis* Scopoli, Fl. Carnolica **2**:466. 1772). It is impossible from SCOPOLI'S description to say to what species he referred. SCOPOLI cites *fig. A*, *plate 37*, of BATARRA (Fung. Agri. Armin. Hist. 1755). There are several of BATARRA'S figures which resemble *P. lucidus* more closely than the one which SCOPOLI cites. BATARRA in turn cites *Agaricum flabelliforme* Micheli (Nov. Plant. Gen. 118. 1729), which from his own and MICHELI'S description evidently applies to some other plant.

Ganoderma lucidum Karsten, Rev. Myc. 3:no. 9, p. 17. 1881.
Ganoderma tusgae Murrill, Bull. Torr. Bot. Club 29:601. 1902; North American Flora 9^2:118. 1908.

Sporophore large, usually stipitate, rarely sessile, annual, rarely perennial, convex above, concave or plane below; pileus dimidiate, reniform, or rarely circular, margin plane or broadly crenate to lobed; surface smooth, sometimes coarsely radiately rugose, incrusted with a reddish or blackish substance shining like varnish, sulcate, the shallow concentric furrows marking off zones which are often narrow and crowded on the margin; trama or context punky, often quite firm and hard especially next the hymenophore, brown to pallid whitish, whitish above, brown next the hymenophore, zonate especially next the stem, though sometimes faintly; stem when present lateral or excentric or rarely central, long or short, sometimes forked, 0.5–4^{cm} in diameter, even or irregular, sometimes enlarged below, varnished and colored like the pileus, context colored like that of the pileus or somewhat darker; hymenophore of long slender tubes, brown within, 3–5 to a mm., mouths circular angular, white or yellowish, finally brown, dissepiments entire, obtuse, thin, acute; spores ovoid to ovate, rounded at the base and slightly inequilateral in side view; wall hyaline, smooth, thickened at the apex into a broad conelike cap which usually collapses, leaving the apex truncate or even depressed, everywhere perforate with numerous slender dark-colored lines which radiate from the endospore through the epispore, 9–11 × 5–8 μ. *Fig. 1.*

A large and attractive plant, very conspicuous because of its brilliant varnished appearance. Common on decaying stumps and trunks of frondose and coniferous trees. There appear to be forms or physiological species in this species. In Europe the form more commonly collected is on frondose trees, and is regarded as typical. The usual color of these is a reddish chestnut.

The forms cannot be well separated into species, though some of them may be regarded as elementary or physiological species or forms. Among these may be mentioned the following:

G. PSEUDOBOLETUM TYPICUM.—On trunks and roots of frondose trees in Europe (also in N. A.?); color reddish chestnut.

G. PSEUDOBOLETUM TSUGAE (Murrill) Atkinson.—On hemlock-spruce (*Tsuga canadensis*) in the United States and British America. Since the form does not grow on wood of frondose trees in America it may be regarded as a physiological

species. In color and other characters it differs but slightly if at all from the typical form.

G. PSEUDOBOLETUM MONTANUM Atkinson.—On dead trunks of Abies in the Jura Mountains. This form is very dark, almost black, much darker than the typical form. Type specimens No. 21007 in herb. Cornell University, and a specimen of the same collection deposited in herb. Museum of Paris. *Fig. 2.*

GANODERMA CURTISII (Berk.) Murrill, North American Flora **9**²:120. 1908.

Polyporus curtisii Berk. Hooker's Jour. Bot. **1**:101. 1849.
Fomes curtisii Sacc. Syll. Fung. **6**:158. 1888.
Ganoderma pseudoboletus Murr. p. p. Bull. Torr. Bot. Club **29**:603. 1903.
Ganoderma flabelliforme Murr. p. p. Jour. Myc. **9**:94. 1903.

Fruit bodies large, corky to woody (sometimes perennial?), stipitate or nearly sessile, stipe lateral, excentric, or central; pileus reniform, or circular when the stipe is central, convex or depressed, 0.5–3^{cm} thick at base, with a thin hard crust, margin obtuse; surface zonate, faintly or quite strongly sulcate, sometimes radiately rugose or corrugated toward the margin, smooth, yellowish or reddish yellow, often with reddish spots or zones, not or rarely varnished (laccate); trama or context punky to woody, softer above, harder below next the hymenophore, pallid to pale brownish, light colored next the upper surface; margin sometimes sterile for a short distance on the under side; hymenophore of slender tubes 0.5–1^{cm} long (or longer), brown in section, pore surface grayish white becoming reddish brown where bruised, tubes 3–7 to a mm., mouths rotund, minute, dissepiments thin, edge obtuse, entire; spores ovoid to ovate, rounded at base and slightly inequilateral in side view; wall hyaline, smooth, thickened at apex into a broad conelike cap, which usually collapses, leaving the apex truncate or even depressed, everywhere perforate with numerous slender dark-colored lines which radiate from the endospore through the epispore, 9–11×5–8 μ; stem 1–15^{cm} long, 1–3^{cm} thick, nearly cylindrical but variable, surface laccate with a reddish-chestnut varnish on the crust, context brown, nearly the same color as the tubes or context of the pileus next the tubes. *Fig. 3.*

On dead roots, stumps, etc. of frondose trees in the southern United States.

GANODERMA OREGONENSE Murrill, North American Flora **9**²:119. 1908.—Sporophore large, stipitate; pileum 14–17^{cm} long, 12^{cm} broad, 5.5^{cm} thick, tumid, upper surface rather strongly convex, hymenophore slightly convex or plane; surface smooth, with a thin

brittle crust, shining as if varnished (laccate), dark reddish brown (seal brown to clove brown, *R* with reddish tinge), sulcate, rings distant on the surface, crowded at the margin, more or less rugose; trama white, cinnamon next the hymenophore, very soft, punky, and yielding like chamois skin, the cinnamon-colored portion firmer; hymenophore of long slender tubes, up to 2–5^{cm} long, often with a stratified appearance, the strata 3–4^{mm} and marked off by faint lighter lines, brown, near cinnamon to Mars brown (*R*), firm, woody, tubes angular, 4–5 to a mm., dissepiments thin, entire; spores elliptical to subovate, rounded at the broader end, in age truncate at the smaller end, attached one side of the broader end, wall perforated by numerous short lines of a brownish substance, giving a verrucose appearance to the spore which is really smooth, 11–15×7–8 μ; stem stout, 1–15^{cm} ×3–6^{cm}, irregular, surface like that of the pileus; trama white, soft like the white part of the pileus, with a radiate, fibrous growth from the middle line and continuing into trama of the pileus. *Fig. 4.*

On dead *Picea sitkensis* near Seaside, and on dead root (of conifer?), Corvallis, Oregon.

Ganoderma subperforatum Atkinson, n. sp.—Sporophore medium size, stipitate. Pileus lateral, simple or lobed, subcircular to reniform, convex, brick red to bay, vinaceous cinnamon toward margin, and the margin lighter color when young, laccate, broadly sulcate; spores ovate-cuneate, content brownish, wall thin, very faintly perforate with slender dark lines, which are seen with difficulty, 8–12× 5–8 μ. *Fig. 5.*

(Sporophorum stipitatum. Pileo suberoso lignoso, sulcato-rugoso stipiteque laterali, laccato, rubro-castaneo; sporae ovato-cuneatae, membraneo leviter perforato ab lineis brunneis, 8–12×5–8 μ.)

On dead oak wood, Chillicothe, Ohio. Type specimen no. 19560 in herb. Cornell University.

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EXPLANATION OF PLATE XIX

Photomicrographs of spores of several species of Ganoderma, ocular 12, objective 1.5^{mm} oil immersion, Zeiss microscope, plate-holder 370^{mm} from object. The photomicrographs were made by the author. The photographs from which the text figures were produced were made by E. J. PETRY under the author's direction.

FIG. 1.—*Ganoderma pseudoboletum* forma *montanum* Atkinson, from plant on fir, Jura Mts., France; some of the spores show the entire conical, hyaline cap at apex; note the dark lines perforating the hyaline wall; the upper right-hand spore is in side view, showing at the lower corner a point where the spore was attached to the sterigma; lower spore slightly out of median focal plane, surface appearing roughened or echinulate.

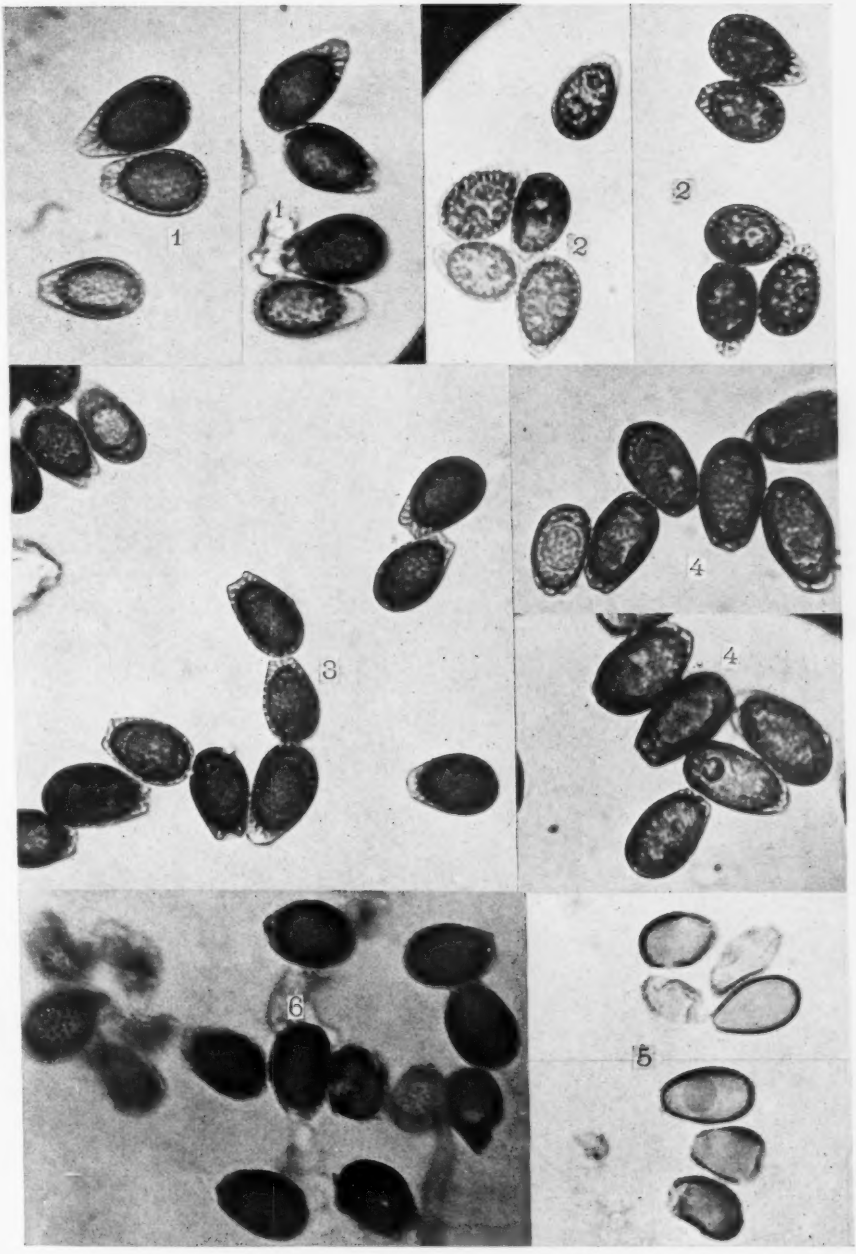
FIG. 2.—*Ganoderma pseudoboletum* forma *tsugae* (Murr.) Atkinson, from plant on hemlock-spruce, Ithaca, N. Y.; a few of the spores show the entire conical cap at the apex; one of the spores of the group in the left is in side view, showing the inequilateral form, and the point where attached to sterigma; note the perforating dark lines in the hyaline wall of the spores; one spore at extreme left slightly out of median focal plane, and these lines appear as echinulations.

FIG. 3.—*Ganoderma curtisii* (Berk.) Murrill; one of the spores at the lower side shows the entire conical cap at apex; this and another one at the left are in side view, showing the inequilateral form; note the perforating dark lines in the hyaline wall; North Carolina plants.

FIG. 4.—*Ganoderma oregonense* Murrill; showing elliptical form of spores, thinner wall, dark perforating lines in wall of spores.

FIG. 5.—*Ganoderma subperforatum* Atkinson, from Ohio; showing cuneate form of spores and faint dark lines in the spore wall, only brought out by boiling in potash solution.

FIG. 6.—*Ganoderma pseudoboletum* typicum, from plant collected in Bois de Boulogne, Paris; most of the spores are out of focus; the dark lines perforating the walls appearing as warts or echinulations, but the spores are really smooth.



ATKINSON on POLYPORUS LUCIDUS

THE MORPHOLOGY OF *PHYLLOCLADUS ALPINUS*

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 118

N. JOHANNA KILDAHL

(WITH PLATES XX–XXII)

The only account of the morphology of Phyllocladus is that of Miss AGNES ROBERTSON (**18**) in 1906, and this deals exclusively with the anatomical structures and with the affinities of the genus.

The material for the present study was collected by Dr. L. COCKAYNE of New Zealand. It consisted of two collections: one of ovulate and staminate strobili, collected November 1, 1906; the other of ovulate strobili, collected December 11, 1906, from cultivated trees. Unfortunately, the two collections did not afford a very close series, and it was impossible to get at some of the most important points, as the development of the microsporangia, microspores, pollen tubes, female gametophyte, archegonial neck cells, ventral cell or nucleus, and embryo. Dr. COCKAYNE is making collections of the lacking stages at the present time, and it is hoped that a complete description can be presented later. Some material was also obtained from Cambridge, Mass., through the kindness of Dr. B. L. ROBINSON, consisting of three ovulate cones, taken from the Gray Herbarium and collected on the Wilkes expedition in 1838–1842. At what time of the year these cones were collected is not known, but they showed somewhat later stages than those of the last collection made by Dr. COCKAYNE on December 11. It is needless to say that this herbarium material was very much shrunken, and it was impossible to obtain from it any definite structure.

Dr. COCKAYNE'S material was killed and fixed in the field, in 70 per cent. alcohol and formalin; cut 5 μ and 7 μ thick; and stained part in safranin and gentian violet, and part in iron alum.

Staminate strobilus

The staminate strobili are formed laterally, in clusters of 2–8 at the tips of the lateral branches. Miss ROBERTSON (**18**) reports one staminate strobilus bearing an ovule at its base, which may indicate

that the ancestral condition was bisporangiate. The sporophyll resembles that of Pinus, although it is comparatively shorter and broader, and has two abaxial sporangia (*fig. 1*). Whether it has any aborted sporangia, as reported in the Taxineae, could not be determined. At least when mature it has fewer sporangia than any of the Taxineae; *Taxus baccata* having seven, *Torreya taxifolia* four, Cephalotaxus four to two, and Phyllocladus two.

Male gametophyte

Material collected November 1 showed the microspores shed and the sporangia wide open along the whole line of dehiscence. Only three or four sporangia retained a few spores, and therefore the sections did not show many stages.

The youngest stage found in the development of the microspore was the uninucleate stage (*fig. 3*), with the wings fully developed. The microspores contain no starch; COULTER and LAND (**9**) found the microspores of *Torreya taxifolia* rich in starch; Miss YOUNG (**20**) found starch in the spores of Dacrydium; the body cell of *Cryptomeria japonica* contains starch grains, according to LAWSON (**16**); COKER (**7**) found the spores of Podocarpus, during all of the divisions, packed with starch, which disappears just before shedding; CHAMBERLAIN (**6**) found starch in the spores of *Pinus Laricio*, and Miss FERGUSON (**12**) in the spores of the species of pine studied by her.

The first division of the microspore cuts off a prothallial cell, which usually lies against the wall, and which immediately begins to disorganize (*fig. 6*). Soon a second prothallial cell is cut off. These two prothallial cells are at first surrounded by delicate walls which very soon disappear, so that when the spore is mature all the four nuclei lie free in the common cytoplasm. The first prothallial cell is commonly evanescent and its nucleus soon disintegrates (*figs. 9, 10*); in two mature spores it was still recognizable (*fig. 11*). The second prothallial cell always persists, in which respect Phyllocladus is similar to Ginkgo.

Prothallial cells have heretofore not been reported in any of the Coniferales except Podocarpineae and Abietineae. COKER (**7**) reports two prothallial cells in Podocarpus, one of which develops further, while the other slowly degenerates. In *Podocarpus Totarra*

Hallii BURLINGAME (**4**) finds two prothallial cells, both of which divide and form a tissue, consisting generally of six cells; a similar condition was found in Dacrydium by MISS YOUNG (**16**). Two more divisions follow, so that the mature spore commonly contains four free nuclei—prothallial, tube, stalk, and body nuclei.

On November 1 the four-nucleate microspores are mostly found lodged on top of the nucellus (*fig. 15*); how much earlier they reach it and how long they remain there is not known, as no material previous to this date was available. In exceptional instances pollen tubes had been formed and had penetrated the nucellus (*fig. 18*); but at this date the tube contained only the four nuclei of the mature spore. On December 11 the nucellus was in most cases entirely honeycombed with pollen tubes, and very much disintegrated (*fig. 19*). The pollen tubes do not pass deviously through the nucellus to any great extent, nor branch, but pass almost in a straight line to the embryo sac. As many as fifteen tubes were found in one ovule (*fig. 19*).

Before the pollen tube enters the embryo sac the body cell divides into two equal and optically similar male cells; it was impossible to observe this division, but it takes place some time after the tube has penetrated the nucellus and before it enters the embryo sac (*figs. 20, 31b*). The entire contents of the pollen tube (five naked nuclei) enter the egg (*fig. 20*). ARNOLDI (**1**) also finds that in Cephalotaxus the contents of the pollen tube are emptied into the embryo sac, the contents in this case, however, consisting of only four nuclei; a similar condition has been found in Pinus, where nearly the whole of the contents of the tube is emptied into the cytoplasm of the egg (COULTER and CHAMBERLAIN **10**, and FERGUSON **12**); according to COKER (**8**) this may also take place in Taxodium (**8**) and in Podocarpus (**7**); and COULTER and LAND (**9**) report it for *Torreya taxifolia*. In Cryptomeria LAWSON (**16**) finds that only one male cell enters the archegonium; and JÄGER (**13**) reports the same in *Taxus baccata*. In Phyllocladus it is not uncommon to find the entire contents of pollen tubes within the embryo sac after fertilization has taken place, and even after the eight-nucleate proembryo stage (*fig. 30*); this is no doubt due to the unusual open condition of the archegonia, the greatly disintegrated nucellus (which seems to be of a very mucilaginous consistency), and the large number of pollen tubes.

When the two male cells are equal, it is commonly inferred that both function. So far as could be determined, only one male cell functions in Phyllocladus, and the second male cell, together with the other three nuclei discharged into the egg cell from the pollen tube, disintegrate as the proembryo develops, as shown in *fig. 26*. ARNOLDI (1) finds in Cephalotaxus that the second male cell remains in the upper end of the egg and later goes through a mitotic division.

The Taxineae are equally divided in regard to the size of the male cells. In *Torreya taxifolia* they are unequal (COULTER and LAND 9); they are also reported unequal in Taxus by BELAJEFF (3), and by JÄGER (13); ARNOLDI reports them of the same size in Cephalotaxus (1); and they are equal in Phyllocladus. Outside of the Taxineae they are equal in *Juniperus communis* (NORÉN 17), Thuja (LAND 15), Sequoia (ARNOLDI 2), *Pinus Banksiana* (COULTER 11), and *Pinus Laricio* (CHAMBERLAIN 6). Miss FERGUSON (12) finds them unequal in *Pinus Strobus;* and one functioning male cell is reported in Podocarpus by COKER (7). LAND (13) finds in *Ephedra trifurca* that the male cells are equal, both enter the egg, but only one functions.

Ovulate strobilus

The ovulate strobilus occurs on the side of the phylloclad (in the axil of a scale leaf) near its base (*fig. 12*). It usually occurs singly, but frequently in pairs; never more than one pair was seen upon a single phylloclad. The strobilus consists of six to eight rather fleshy scales, each scale bearing a single ovule in its axis.

The ovule has two integuments, entirely free from the nucellus to the very base. The inner one is very thick and consists of three layers: an inner fleshy, a middle stony, and an outer fleshy consisting of only two layers of cells. The stony layer begins to develop at the micropylar end and extends toward the base. At first it consists of only one layer of cells, but later it becomes much thicker and extends all the way around the base of the ovule, where, however, it remains much thinner than at the micropylar end. The inner fleshy layer is somewhat crowded out by the growth of the stony layer; and the outer fleshy layer is finally sloughed off. The integument contains no vascular strands; these end at the base of the ovule (*fig. 15*); it contains a number of resin ducts, shown in the cross-section in *fig. 16*.

The second integument, called an arillus, arises quite late outside of the heavy integument; on November 1 it appears merely as a small papilla in longitudinal section (*fig. 15*). It grows very rapidly, inclosing the ovule like a cup; the ovule, however, grows up through it, and by December 11 it is merely a light, leathery sheath around the base of the ovule, reaching about half-way to its tip (*fig. 14*).

Female gametophyte

It was impossible from the material in hand to ascertain the development of the female gametophyte, as the formation of walls was in most cases well advanced on November 1. In a few instances it was still in the free nuclear stage (*fig. 18*); and one preparation showed archegonia already formed. The endosperm is of the "ruminating" type, this feature being especially pronounced in the early stages.

The development of archegonia could not be observed, as no stage before fertilization was available. It is impossible, therefore, to state definitely whether neck cells are formed or not. Some indefinite remains of cells, in a few sections, indicate that they exist; and comparing Phyllocladus with the Taxineae, and taking into consideration that neck cells are often destroyed very early by the pushing-in of the pollen tube or the growth of the central cell, the probability is that a two-celled neck exists in the early stages of the archegonium (*fig. 32b*), although nothing was found upon which a definite statement can be based. In *Torreya taxifolia* COULTER and LAND (**9**) found two neck cells; ARNOLDI (**1**) also found two in *Cephalotaxus Fortunei;* JÄGER (**13**) reports two in *Taxus baccata.* From such a condition as that shown in *figs. 19, 31, 32,* it may be inferred that the presence or absence of neck cells would make very little difference. The whole structure of nucellus and gametophyte is of a very mucilaginous composition, and this, together with the prodigality of pollen tubes and male cells, presents a very loose and disintegrated condition. The archegonium in every case, whether located near the surface of the gametophyte or deeper in the tissue, presents an opening as large as the width of the sac. The pollen tube penetrates the tissue, digesting it very readily, and seems to break through the layer of jacket cells surrounding the embryo sac as though no obstacle were in its way. No instance was

found, at the stage of fertilization, where the archegonium had not been smashed into, either from the top or from the side, by the pollen tube.

The embryo sac is surrounded by a layer of jacket cells with very large nuclei, and many of the cells are multinucleate. JÄGER (13) also pictures a very heavy jacket layer of uninucleate cells in *Taxus baccata;* none are reported in Torreya or Cephalotaxus, although the drawings of the latter by ARNOLDI (1) suggest a jacket layer. The archegonia are one to four in number.

No ventral cell or nucleus could be demonstrated, although the probability is that a ventral nucleus is formed; the chromatin in the egg nucleus (*fig. 32b*) before fertilization indicates that it is getting ready to divide. ARNOLDI (1) says that in *Cephalotaxus Fortunei* the egg nucleus, shortly before fertilization, cuts off a ventral canal nucleus, which together with a mass of the upper part of the egg destroys the neck cells and passes out of the embryo sac. JÄGER (13) does not mention nor picture a ventral nucleus in Taxus; COULTER and LAND (9) did not find a ventral cell or nucleus in *Torreya taxifolia;* Miss ROBERTSON (1) interpreted a spindle in the central cell of *Torreya californica* as the forming of a ventral nucleus.

Fertilization

At the time of fertilization the egg becomes rich in food vacuoles in the basal end (*figs. 25, 26, 28*). The egg nucleus may be situated near the upper end of the egg (*figs. 22, 23*), or near the basal end (*fig. 28*). The fusion nucleus (*figs. 22, 24*) is partially surrounded by the finely granular cytoplasmic sheath of the male nucleus. This cytoplasmic sheath has been observed in Taxodium by COKER (8), in *Torreya taxifolia* by COULTER and LAND (9), and in *T. californica* by Miss ROBERTSON (19). The non-functional male cell (*figs. 22, 23*), which has begun to disorganize, shows the cytoplasmic sheath very distinctly.

Embryo

The first division of the oospore could not be obtained. Free nuclear division was observed to the eight-nucleate stage. As this was the oldest stage available, it is impossible to say whether more free nuclei are formed or not before the formation of walls. ARNOLDI (1) figures ten free nuclei in one section of *Cephalotaxus Fortunei,*

and states that there are eight to sixteen free nuclei. JÄGER (13) found sixteen free nuclei in the proembryo of *Taxus baccata;* and COULTER and LAND (9) found four free nuclei in *Torreya taxifolia.* One of the older ovules showed a long suspensor and an embryo of a few cells buried near the base of the gametophyte (*fig. 33*), but it was impossible to make out its structure.

Summary

The microsporophyll has two abaxial sporangia and the microspores are shed on November 1 or before.

Two prothallial cells are formed, the first of which is generally evanescent; sometimes both persist as free nuclei, the walls of both being evanescent.

The mature microspore has usually four free nuclei, and occasionally five.

The ovulate strobilus is borne on the phylloclad, and bears two to eight ovules.

The ovule has two integuments; one thick and fleshy, the other (arillus) thin and leathery and persistent only at the base. They are free from the nucellus to its base, and contain no vascular strands.

Microspores are found resting on the top of the nucellus on November 1, and occasionally pollen tubes and archegonia are formed at this date.

Pollen tubes are very numerous and pass in a comparatively straight line through the nucellus to the archegonium. They smash the neck cells, if there are any, and empty their entire contents into the egg; the contents of one or more pollen tubes were found in an egg after the eight-nucleate stage of the proembryo.

The body cell divides into two equal male cells just before discharge into the egg; and only one male cell functions.

The archegonium is surrounded by a heavy jacket layer, consisting of multinucleate cells with large nuclei. Two neck cells are probably formed. No ventral cell or nucleus was found, but the material does not justify a definite statement as to its occurrence or not.

The male cell is surrounded by a cytoplasmic sheath which, partly at least, surrounds the fusion nucleus.

At least eight free nuclei are formed by the proembryo before cell walls are formed; and a long suspensor is developed.

This work was carried on under the direction of Professor JOHN M. COULTER; and my acknowledgments are also due to Dr. C. J. CHAMBERLAIN and Dr. W. J. G. LAND, for kindly assistance.

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EXPLANATION OF PLATES XX–XXII

With the exception of *figs. 1* and *2* all the figures were drawn with the aid of a camera lucida and reduced one-half. Index letters are as follows: *e*, endosperm; *p*, perisperm; *n*, nucellus; *if*, inner fleshy layer; *s*, stony layer; *of*, outer fleshy layer; *a*, arillus; *fs*, fleshy scale.

PLATE XX

FIG. 1.—Abaxial view of microsporophyll, showing the empty sporangia.

FIG. 2.—Side view of microsporophyll.

FIG. 3.—Microspore. ×1850.

FIG. 4.—First division of microspore. ×1850.

FIG. 5.—Two-nucleate stage. ×1850.

FIG. 6.—Second division; first prothallial cell against upper wall. ×1850.

FIG. 7.—Three-nucleate stage, showing form of wings. ×3000.

FIG. 8.—Evanescent walls of the two prothallial cells. ×3000.

FIG. 9.—First evanescent prothallial cell lying outside of the cytoplasm of the spore. ×1850.

FIG. 10.—Mature microspore. ×1850.

FIG. 11.—Microspore with both prothallial cells retained. ×3000.

FIG. 12.—Phylloclad with ovulate strobilus.

FIG. 13.—Outer view of fleshy scale with ovule.

FIG. 14.—Inner view of fleshy scale with ovule, showing arillus.

FIG. 15.—Longitudinal section of ovulate strobilus, showing ovules with integuments, fleshy scales, and position of vascular system, November 1. ×40.

FIG. 16.—Cross-section of ovule; archegonia in the center of the endosperm; November 1. ×40.

FIG. 17.—Longitudinal section of the ovule with fleshy scales; micropyle not yet formed; arillus covering the ovule; November 1. ×40.

PLATE XXI

FIG. 18.—Part of nucellus on November 1, showing pollen tubes and part of the female gametophyte in the free nuclear stage; archegonia not yet formed; body cell not yet divided. ×850.

FIG. 19.—Nucellus showing numerous pollen tubes and open archegonia; nearly all the body cells have divided; December 11. ×180.

FIG. 20.—Pollen tube, containing two male nuclei, the stalk and tube nuclei, and one prothallial nucleus, entering the archegonium. ×1850.

FIG. 21.—Archegonial jacket cells. ×3000; *fig. 21a*, same.

FIG. 22. Fertilization: the fusing nuclei are partially surrounded by the cytoplasmic sheath; the second male nucleus lies above the fusing nuclei and has begun to degenerate. ×3000.

FIG. 23.—A later stage in fertilization. ×3000.

FIG. 24.—Fusing nuclei with cytoplasmic sheath. ×1850.

FIG. 25.—Second division of proembryo. ×3000.

FIG. 26.—Four-nucleate stage of proembryo; the other four nuclei degenerating. ×3000.

FIG. 27.—Section through thick integument showing inner fleshy layer, the row of heavy-walled cells (containing crystals) which becomes the stony layer, and the outer fleshy layer of two rows of cells. ×1850.

PLATE XXII

FIG. 28.—Basal end of egg, showing egg nucleus, pollen tube with two male nuclei and one other nucleus, and food vacuoles. ×1850.

FIG. 28*b*.—The archegonium of *fig. 28*, showing position of egg nucleus and pollen tube in the egg. ×100.

FIG. 29.—Basal end of embryo sac, showing four nuclei of the proembryo, remains of the pollen tube, and the non-functional male cell. ×1850.

FIG. 29*b*.—Same as *fig. 29*, showing whole length of embryo sac. ×100.

FIG. 30.—Eight free nuclei of proembryo in basal end of sac, with pollen tube above containing normal contents. ×1850.

FIG. 30*b*.—Same as *fig. 30*, showing top of embryo sac. ×100.

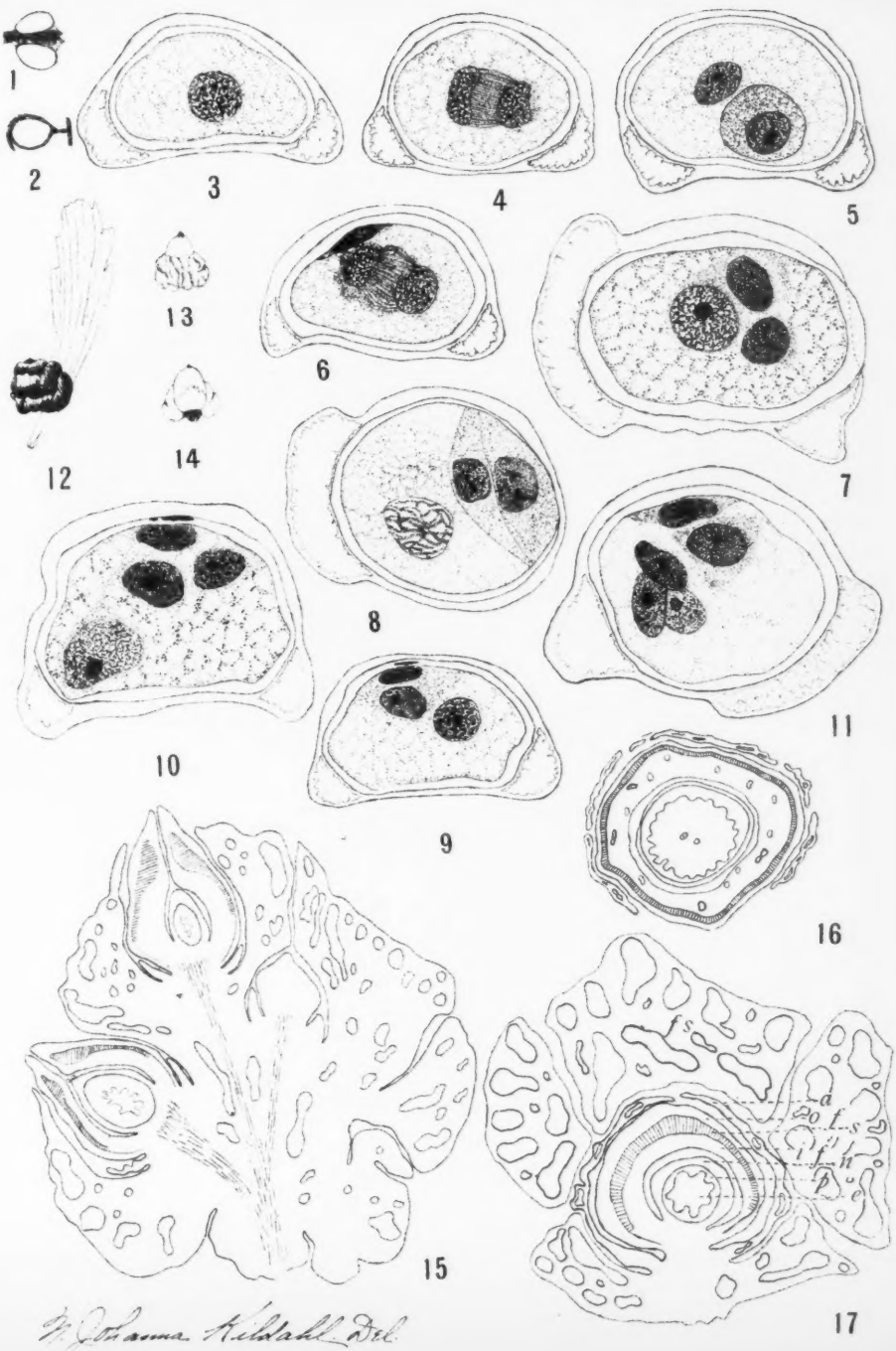
FIG. 31.—Female gametophyte, showing disintegration by pollen tube; the pollen tube is entering the egg from the side. ×100.

FIG. 31*b*.—Same as *fig. 31*. ×1850.

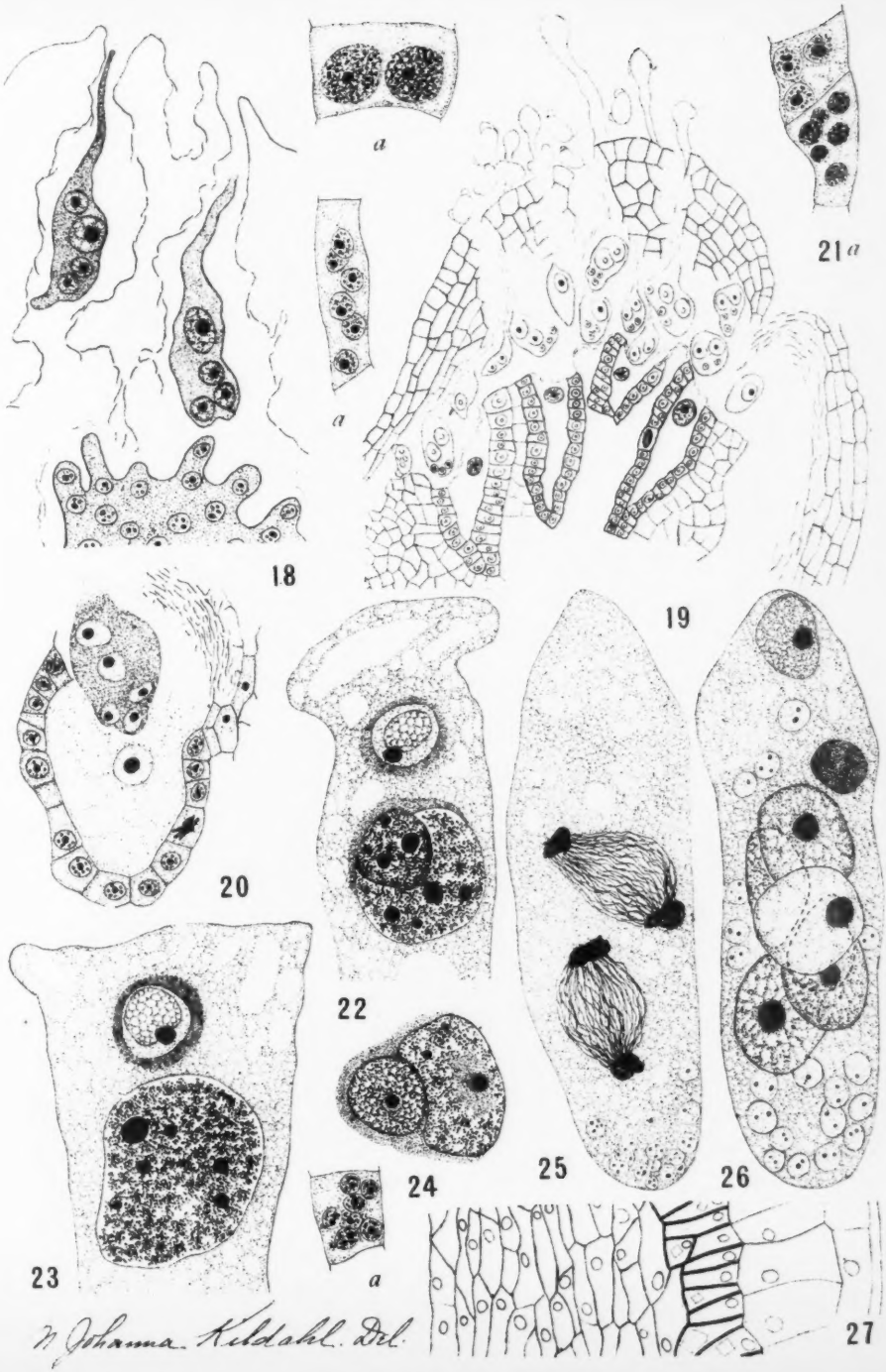
FIG. 32.—This figure shows the straight path usually made by the pollen tubes through the nucellus to the archegonia. ×100.

FIG. 32*b*.—Same as *fig. 32*, showing the two probable neck cells; the loose structure of the chromatin of the egg nucleus intimates that it may form a ventral nucleus; body cell not yet divided. ×1850.

FIG. 33.—Long suspensor, with embryo buried deep in the female gametophyte. ×100.



KILDAHL on PHYLLOCLADUS



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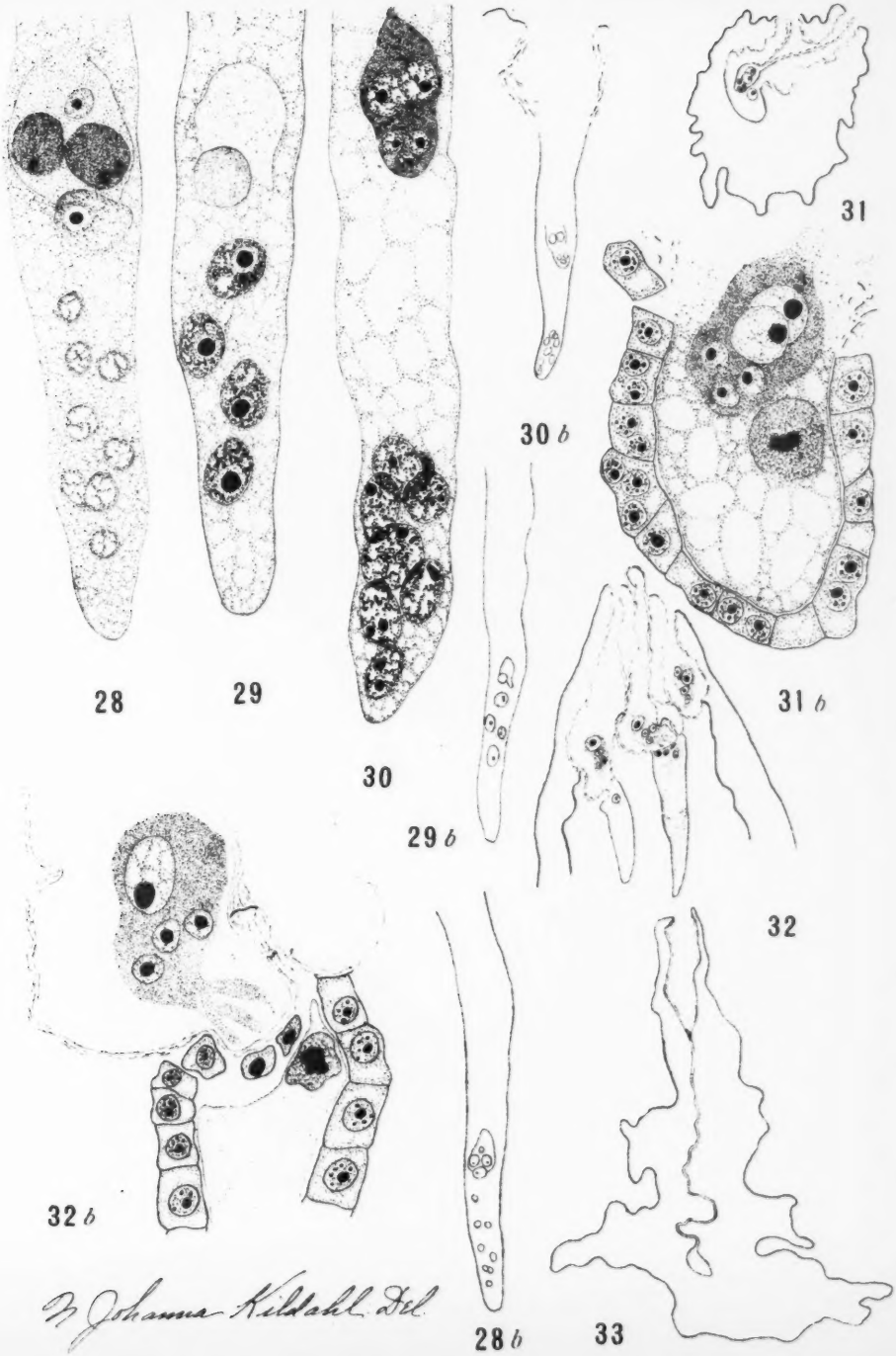

KILDAHL on PHYLLOCLADUS

NOTES ON NUMERICAL VARIATION IN THE DAISY

C. H. DANFORTH

Numerous observers, both in this country and in Germany, have given attention to numerical variations in the ray florets of the Compositae. For the investigation of the subject the common daisy, perhaps, has been most frequently used. The usual method of study has been simply to count and tabulate the ray florets for a number of heads collected from some prescribed locality. The results of such observations seem to show that the number of ray florets in the daisy is subject to a considerable amount of variation; but when a frequency curve is plotted, more or less definite modes become evident, one on the 21-ray line being especially prominent.

TABLE I

DISTRIBUTION OF RAYS FOR 4000 HEADS COLLECTED AT MEDFORD, NORWAY, AND DENNIS

Rays	Heads
12	1
13	9
14	4
15	9
16	12
17	12
18	25
19	49
20	135
21	423
22	370
23	295
24	278
25	216
26	204
27	176
28	191
29	192
30	184
31	224
32	218
33	266
34	303
35	115
36	47
37	27
38	9
39	3
40	3

With a view to getting more data, I examined 4000 heads during the summer of 1905, from which I obtained results that agree in general with those previously obtained by TOWER, and by PEARSON and YULE from a much smaller number of heads, except that their data do not demonstrate the presence of a mode on 34, as do my own observations and those of LUDWIG (**3**). For the investigation in question I collected 1300 heads from the vicinity of Tufts College, Medford, Mass.; as many more from Norway, Oxford County, Maine; and 1400 from Dennis, Cape Cod, Mass. In these lots 12 was the lowest number of rays found in any one head and 40 was the highest. The total number of rays produced by the whole lot was

107,464, which gives a mean of 26.866 to the head. The distribution of these rays is indicated in Table I. It will be observed that were these figures plotted the result would be a two-humped curve, indicating modes on 21 and 34.

If I combine with my own figures those given by TOWER (**6**) and by PEARSON and YULE (**4**), the resulting table (Table II) will be based on a total of 140,988 ray florets from 5585 heads, collected from five different localities by several different observers. It may be observed that this table indicates modes on 21 and 34. The mean number of rays to the head for this set is 25.242+. These results coincide with those which have been obtained in Germany in that modes are evident on 21 and 34; but differ from them in that no modes appear on 13 or 8, the next lower terms of the Fibonacci series. In fact, out of the whole number only 6 heads had less than 13 rays and none had less than 11. On the whole, then, observations seem to show that the daisy of this country has prevailingly more rays than the European plant, but that the numbers produced fall around the same modes which have the same relative prominence, except that no obvious modes occur on 13 or 8 in the American material so far examined.

TABLE II

DISTRIBUTION OF RAYS FOR 5585 HEADS, BASED ON DATA OBTAINED BY TOWER, PEARSON AND YULE, AND DANFORTH

Rays	Heads
11	1
12	5
13	40
14	43
15	51
16	67
17	67
18	110
19	141
20	313
21	752
22	536
23	390
24	342
25	279
26	252
27	212
28	217
29	219
30	201
31	254
32	242
33	307
34	325
35	122
36	53
37	27
38	9
39	5
40	3

Such facts have generally been construed as indicating that no essential alteration has taken place in the flowers of our daisy since its introduction into this country, but FERNALD (**2**) has lately called attention to the fact that the common American form is not the typical *Chrysanthemum Leucanthemum* L., but a variety (*pinnatifidum* Lecoq and Lamatte) not usually met with in Germany. Con-

sequently the probablity is that all German data are based on the typical *Chrysanthemum Leucanthemum*, while all American data are doubtless based on var. *pinnatifidum*. In view of this fact the value of comparisons between the two forms may at first seem doubtful, but a slight further consideration of the character of numerical variations of the present kind may throw some light on the way in which such variations should be regarded.

SHULL (**5**), working with Aster, concluded that there is no tendency for all the flowers of the same plant to fall in the same mode, but that those that blossom first have the greatest amount of nourishment and therefore show the highest modes. TOWER (**6**) likewise thought that in the daisy the higher modes are met with early in the season, the lower modes later. In other words, it would seem that these authors are inclined not to regard the several modes as indicative of incipient species. My own observations, I think, fully substantiate their views in this particular. A comparison of Tables III and IV will show clearly a change in the predominant mode from 34 in the material collected between May 27 and June 14, to 21 in material collected between July 3 and July 15. Although this comparison may not be taken as certain evidence, inasmuch as the two lots were from different localities, nevertheless there is a strong suggestion here of a connection between mode and season.

TABLE III

DISTRIBUTION OF RAYS FOR 1300 HEADS COLLECTED IN MEDFORD BETWEEN MAY 27 AND JUNE 14, 1905

Rays	Heads
12	
13	1
14	
15	1
16	
17	
18	3
19	5
20	19
21	78
22	95
23	80
24	84
25	58
26	58
27	72
28	64
29	65
30	68
31	79
32	83
33	121
34	154
35	63
36	20
37	18
38	7
39	3
40	1

Two pairs of tables, one based on material collected at Norway, Maine, the other on material collected at Dennis, Mass., give much clearer evidence of the relation between mode and environment.

The collections from Norway were taken on June 22, 1905, from the two sides of a private road, about 12 feet wide, which several years previously had been run through an open field. The ground slopes in such a manner that the north side of the road receives practically all of the drainage, while the south side is drier and less favorably supplied. Noticing an apparent difference in the daisies of the two sides of the road, I marked a starting point and picked every head within about two feet of the road, till 150 had been collected from each side. The table (Table V) based on the counts shows clearly a tendency for the heads growing on the north side of the road to have a large number of rays, and for those on the south side to have a much smaller number. This difference between the two lots, it seems to me, may be regarded as clearly indicating a relationship between the amount of moisture or nutrition and the number of ray florets.

TABLE IV

DISTRIBUTION OF RAYS FOR 1300 HEADS COLLECTED IN DENNIS BETWEEN JULY 3 AND JULY 15, 1905

Rays	Heads
12	1
13	8
14	4
15	6
16	9
17	5
18	16
19	32
20	62
21	176
22	139
23	99
24	84
25	72
26	75
27	43
28	52
29	66
30	52
31	66
32	64
33	68
34	75
35	14
36	7
37	2
38	2
39	
40	

Very similar results were obtained from two lots of 250 heads, each collected at Dennis, July 13 and 14. One of these lots (Table VI, *B*) was from a rosebush tangle near the sea; the other (Table VI, *A*), was from a dry field near by. These lots likewise show clearly a tendency for plants growing in more moist and richer soil to have a higher number of rays.

These various observations seem to indicate that the number of ray florets in the daisy is in part conditioned by two general factors: an external factor, nutrition; and another, which might possibly be termed internal, namely, the tendency which gives rise to modes. A slight investigation of the latter has led me to believe that the explanation of the

modes is to be sought in an explanation of phyllotaxis. As is well known, this is a subject which has given rise to a great deal of speculation. Although, perhaps, there is even now no satisfactory explanation of the rules of phyllotaxis, the facts themselves are familiar and only a brief reference need be made to one or two simple conditions.

As has been frequently pointed out, five-ranked leaves may be regarded as arranged on the stem according to any one of several different schemes. In one light they may be imagined as situated regularly along a line coiled spirally around the stem in such a way that the sixth leaf falls very nearly above the first. In this case, if the line is considered as running around the stem in one direction, it encircles it twice in passing from the first to the sixth leaf; if in the other direction, it encircles it three times in passing between the same two points. On changing the point of view slightly, the leaves may be imagined as all arranged along two parallel spiral lines running in one direction, or along three similar lines running in the opposite direction, in which case either spiral embraces five leaves in each revolution. This is equivalent to regarding the leaves as though they were placed at the points of intersection of two opposite sets of spirals, one composed of two lines, the other of three. Once more, the leaves may be regarded as placed along five nearly vertical but still slightly spiral lines. Of course these are merely different ways of regarding one and the same thing.

TABLE V

DISTRIBUTION OF RAYS IN TWO LOTS OF 150 HEADS EACH; MATERIAL COLLECTED AT NORWAY, JUNE 22, 1905; LOT *A* FROM SOUTH SIDE OF ROAD; LOT *B* FROM NORTH SIDE OF SAME ROAD

Rays	Heads	
	A	*B*
16	1	
17	4	
18	2	
19	4	
20	20	
21	37	2
22	26	5
23	15	7
24	8	8
25	3	8
26	2	10
27	4	5
28	6	8
29	5	8
30	4	6
31	4	13
32	2	14
33	1	17
34	1	17
35		10
36	1	5
37		5
38		
39		
40		2

While these conditions, on the whole, are quite constant, nevertheless when the stem is increased in diameter or shortened, thereby

bringing the leaves or their morphological equivalents closer together, the parts not infrequently become arranged according to an apparently different scheme. Thus in the umbels of the wild carrot (*Daucus Carota*) peduncles are usually so arranged that they seem to be placed at the intersections of what appear to be lines arranged in the form of logarithmic spirals (see CHURCH 1), eight running in one direction and five in the other; or, if the umbel is large, eight in one direction and thirteen in the other. This arrangement might be considered as differing from the arrangement of five-ranked leaves only in the greater number of intersecting spirals. The point of chief interest in the present connection is that the number of spirals is confined rather constantly to the lower members of the logarithmic series 1, 2, 3, 5, 8, 13, 21, 34, etc.

TABLE VI

DISTRIBUTION OF RAYS FOR TWO LOTS OF 250 HEADS EACH; MATERIAL COLLECTED AT DENNIS, JULY 13 AND 14, 1905; LOT *A* FROM A DRY FIELD; LOT *B* FROM A ROSEBUSH TANGLE NEAR BY

Rays	Heads	
	A	*B*
12	1	
13	6	
14	3	
15	2	
16	6	1
17	3	1
18	7	2
19	12	7
20	22	9
21	55	27
22	27	12
23	23	14
24	12	12
25	16	12
26	13	18
27	4	4
28	3	11
29	7	18
30	5	15
31	7	28
32	5	16
33	5	16
34	6	21
35		2
36		2
37		1
38		1

If now a daisy head be examined carefully, it will generally (perhaps always) be found that the disk florets are so arranged that they appear to be placed at the intersections of two sets of spirals; or perhaps they might be more conveniently regarded as arranged in either of two opposed sets of spirals running from the periphery to the center of the head. I shall speak of the disk florets, therefore, as though they were arranged in two sets of spirals, although each of these sets (which one depending on the point of view assumed) embraces all the florets. There are usually 21 spirals running one way and 13, 21, or 34 running the other way. The set of 21 spirals may be either left-handed or right-handed in direction; but in either case the direction of the spiral is apparently correlated with the arrangement of the

leaves. Only 100 plants were examined to determine this relationship, but among these specimens, which were collected at Norway in June, 1908, I found no exception to the rule that the direction of a set of 21 spirals in the disk is similar to the direction of the shortest line that can be drawn from any leaf on the stem to the next succeeding leaf. That is to say, if a stem was so held that any given leaf faced the observer, and it was seen that the next higher leaf on the stem was toward the left rather than toward the right, then a set of 21 left-handed spirals was invariably found in the disk. Of the 100 heads examined, the 21 spirals were found to be left-handed in 47 cases and right-handed in the remaining 53 cases. Of course the direction of the leaf spirals varied accordingly. There can hardly be any indication of incipient species here, for the arrangement on the branches of large plants is, as frequently as otherwise, reversed in reference to the arrangement on the main stem. I have been unable to trace the transition from the placing of the leaves to that of the flowers, except to notice the above-mentioned correlation.

The ray florets are placed, as one might expect, at the peripheral ends of these spirals. Each of the spirals in the set of 21 generally has a ray floret at its end; and frequently there are no other rays, especially if the other set consists of 13 or 21 spirals. When there are 34 spirals in one set, however, and the head is large, the number of ray florets is frequently increased, when each of the 34 spirals may be terminated by a ray. This case, though common, is less frequent than the other. Instances frequently occur where rays do not develop at the ends of some of the spirals, or (less commonly) where two rays develop on the same spiral. Heads that show more than 34 rays are of this class. In some of the Compositae, for example in Erigeron, where the disk florets are arranged in no more spirals than we find in the daisy, there are many rays; but in such cases several flowers of each spiral develop as rays, while in the daisy there seems to be but slight tendency for more than one flower to so develop.

If the typical *Chrysanthemum Leucanthemum* shows as much tendency for developing more than one ray on some of the spirals as does the var. *pinnatifidum*, it would seem hazardous to regard any

comparison between the numbers of ray florets so far recorded as of taxonomic importance, inasmuch as the variations seem to be merely equivalent to variations in size.

In short, the conclusions these observations seem to warrant are: (1) that the florets in the heads of *Chrysanthemum Leucanthemum pinnatifidum* may be regarded as arranged in either of two sets of spiral lines; or, what amounts to the same thing, in the intersections of these two sets of spirals; (2) that the number of lines in each set is a term of the Fibonacci series; (3) that the number is influenced by external conditions, i. e., the conditions of nutrition affecting size; (4) that one set is composed of 21 spirals, which are in some way correlated in their arrangement with the arrangement of the leaves; (5) that each of the 21 spirals and frequently each of the spirals in the other set tends to have a ray developed at its end—hence the modes noted by various observers; and (6) that these facts supply few if any data of taxonomic value.

TUFTS COLLEGE, MASS.

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THE VASCULAR ANATOMY OF THE SEEDLING OF *DIOON EDULE*

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 119

REINHARDT THIESSEN

(WITH PLATES XXIII–XXIX)

This investigation was begun during the winter of 1906, the original purpose being to clear up the confusing statements in reference to the so-called girdling habit of the leaf trace. As the work progressed, its scope became extended, until finally it included all of those anatomical features of the seedling that have a bearing upon the relationship of the Cycadales to the Cycadofilicales and Filicales.

I wish to express my appreciation of the constant encouragement received at all times from Dr. JOHN M. COULTER, under whose direction the work was carried on; I also wish to thank Dr. C. J. CHAMBERLAIN for kindly furnishing the material.

Historical

The first work on *Dioon edule* was by METTENIUS (4), who compared it with *Cycas revoluta*, which was the special form investigated. The methods of those days (1861) did not permit tracing the various vascular bundles throughout their course. Sections were cut only here and there, and the large number of bundles presented only a very incomplete and vague idea to the investigator, resulting in complete misapprehension.

The picture of the leaf trace girdle as METTENIUS drew it is in the main as follows. A bundle in its course toward a leaf divides soon after leaving the central cylinder, the two branches in turn soon dividing. These branches and branchlets, in the main retaining their radially ascending direction, but running at various angles, anastomose with one another and with branches of neighboring bundles, and finally unite with bundles which girdle the vascular cylinder. This girdle lies closest to the ring at a point diametrically opposite the leaf base which its ends enter, each of which therefore traverses the cortex through an arc of about 90°, gradually separating farther from it and

finally entering the leaf base. There is such a girdle for every leaf, and every girdle must cut, on account of its course and location, every other like girdle in two places. Every girdle receives on its inner edge branches from the central vascular bundles which leave the vascular cylinder at various places, and sends out branches from its outer edge to other girdles. From this vague conception, which does not at all agree with the drawings of METTENIUS, the current text-book accounts have been drawn. These accounts, however, do not really interpret METTENIUS, but are as far from his interpretation as that was from the true situation.

In his description of the structure of the bundles METTENIUS was more fortunate, and made a very important contribution. He says that those bundles which are to leave the vascular cylinder are marked off by broad medullary rays and are more definitely bounded than those which continue in the cylinder; that on the inner edge they are provided with spiral vessels (protoxylem), while the others are provided with reticulated cells in the same relative position. At the region of the outward bend of the trace the vascular elements are grouped with the spiral elements on the inner or upper side, immediately bordering the reticulated elements beneath; and this structure the girdle retains in encompassing the stem. Before entering the leaf, however, a change in structure begins to occur, and is completed in the lower part of the petiole; after which the bundle remains unchanged up to the pinnae. The first indication of this change is the appearance of thin-walled cells in the vicinity of the spiral (protoxylem) elements, separating them from the reticulate elements. During the further course of the bundle the spiral (protoxylem) elements gradually move farther within, and the wood is now divided into two parts by the thin-walled cells; the inner part developing its elementary constituents centripetally, and the outer part centrifugally. Finally the spiral (protoxylem) elements are found in the outer part of the bundle, and the centrifugal part is still more reduced, while the centripetal part has reached its maximum development. This structure of the bundle is retained in its further course in the petiole until in the pinnae, where in *Dioon edule* the centrifugal wood is lost altogether. Such is a very brief statement of the description of the transition from centrifugal to centripetal xylem in the leaf traces, as

given by METTENIUS. It was the first correct statement of the facts, but their meaning was probably not understood until an interpretation of the situation was given in 1886 by BERTRAND and RENAULT (**5**).

The second paper upon the vascular anatomy of Dioon is that of MATTE (**6**), a brief description of the anatomy of two seedlings being given. In one of them, a very young seedling, the cotyledons were unequal, the larger having four vascular bundles, and the smaller having two small bundles, but with two other very small strands at the very base, one on each side of the other bundles. The bundles continue in a vertically descending course until where the foliar bundles, after being arranged in a circle, have been reduced to four large bundles, separated by medullary rays. The six cotyledonary strands turn now abruptly toward the three poles (protoxylem groups) of the root, converge, and unite two by two in front of them, effecting an entrance through the medullary rays separating the foliar bundles, and unite their phloem with the phloem of the stem. Their secondary xylem unites laterally with that of the stem, while the primary xylem seems to be in direct continuity with the tracheal poles (protoxylem groups) of the root. The centripetal xylem disappears in the passage across the medullary rays.

In the description of the older seedling MATTE found in each cotyledon four bundles of equal size. Their course and method of union is comparable with that found in the other seedling, and they still unite two by two in converging toward the poles (protoxylem groups), but these poles are four in number.

MATTE touches also upon the girdling habit, ascribing it to an intercalary growth produced under the influence of the development of new interior leaves. The vascular strands of the youngest leaves pursue a vertical course, but those of the older ones an oblique course, a comparison of leaves of different ages showing that this departure from a direct course is due to intercalary growth.

Methods

Embryos were removed from mature seeds and killed in chromo-acetic acid, imbedded in paraffin according to the usual methods, cut with a rotary Minot microtome, and mounted in series, much care being taken that no sections were lost or misplaced. When only the

location or outline of the bundle was wanted, the cross-sections were cut 20 to 30 μ thick; in other cases they were cut 10 μ thick. Longitudinal sections were cut at right angles to the inner surfaces of the cotyledons, as well as parallel to that plane; these were cut 10 μ thick. Staining was done on the slide with safranin and Delafield's hematoxylin, or safranin and anilin blue. Other stains were tried, but these two combinations gave by far the best results. A few specimens were killed by the general picro-mercuric-chlorid method, but no advantage was gained.

Where seedlings were required, the hard coats of the seeds were cut partly open at the micropylar end, and the seeds placed on one side, partially pressed into moist earth, in a flower pot, and put in a warm moist place in the greenhouse and kept well watered. A good many seeds had been planted three years before and had grown to considerable size, some of them having a stem 100^{mm} in length and 25^{mm} in diameter, and bearing several leaves. These were treated about as the embryos, except that all the specimens were cut into lengths of 15 to 20^{mm}. Of course the greater the size of the plant the more slowly the processes of killing, washing, embedding, etc., were conducted. Especial care had to be taken in imbedding the larger specimens, the best results being obtained when they were carried through the process of penetration with paraffin for a whole month. After this time they could be cut with an ordinary Minot rotary microtome with perfect ease, and the sections could be held in complete ribbons. After this precaution, ribbons were obtained from specimens 26^{mm} in diameter and cut 10 μ thick. Staining was done as before with safranin and Delafield's hematoxylin, or safranin and anilin blue, the former combination giving the most satisfactory results. An enormous amount of labor is necessary and also much care to keep sections of entire plants in serial order, both in cross and longitudinal sectioning, but it is the only satisfactory method.

In order to obtain the details or to follow up the leaf trace courses, every section was examined, from the first to the last, and camera drawings made of every second or third section. These were carefully numbered and kept in series and later compared, and reconstructions were based upon them.

Observations

THE EMBRYO

EXTERNAL STRUCTURE.—In the mature seed the cylindrical embryo is fully two-thirds as long as the endosperm, averaging 20^{mm} in length and about 4^{mm} in diameter. The hypocotyl (*fig. 1*) is comparatively very short, being about 5^{mm} long, ends abruptly (very often is even concave), and in the center is still attached the slender, very much twisted and coiled suspensor (*s*). The cotyledons are free for the upper four-fifths of their length, the lower fifth forming a tubular sheath (*sh*) inclosing the leaf primordia (*figs. 2, 3*). One of the cotyledons is slightly larger than the other, and is inserted a little lower on the axis, slightly enfolding the smaller one. There are generally two leaf primordia, but sometimes three. The broad base of the outer or older one (L_1) embraces the inner and next younger one (L_2), which in turn often embraces a third (L_3); and finally beneath them all is the stem tip (*st*). On the oldest leaf primordia are all the rudiments of the pinnae (*pn*) of the future leaf quite well advanced; while no indication of them can be detected on the younger primordia.

To understand certain features to be described later, it is necessary to note the arrangement of the earlier leaves. An older plant (*fig. 7*) may be used as an illustration, and both scales and foliage leaves will be spoken of as leaves and numbered from *1* to *9* according to age. The cotyledons (*cot*) are apparently exactly opposite; *1* and *2* are approximately opposite, but close observation shows that they are not exactly so; also *1* and *2* are approximately at right angles to the cotyledons (also *fig. 2*). The sheathing leaf base of *1* is a little longer and more slender on the side toward which the spiral turns, and folds around the inner leaf or scale a little farther than it does on the other side. Leaf *3* lacks still more of being opposite *2;* also the corresponding edge of the sheathing base of *2* is more slender and folds over *3* more than its fellow. Leaf *4* lacks still more of being opposite *3*, and again the sheathing base is more slender and folds around the next inner leaves more on that side toward which the spiral turns. In the rest of the series the spiral is uniform, and the overlapping more conspicuous.

INTERNAL STRUCTURE.—The bulk of the embryo is of course

parenchymatous, and the general structure is shown in *figs. 2–6, 8, 9, 29–35*.

The epidermis (*ep*) consists of large, regular, isodiametric cells with large nuclei. That of the cotyledons is abundantly supplied with stomata on the exterior surface of the tubular part and a small portion of the lobes. No stomata occur on the part of the cotyledons remaining in the endosperm, on the interior surface of the cotyledons, or on the primordia. The epidermis of the petioles and bases of the leaf primordia is covered densely with long, unicellular hairs, with well-defined nuclei (*figs. 28, 29*).

The ground tissue is composed of long, regular, prismatic cells, much longer than wide in the cotyledons, but shorter and more isodiametric in the stem proper (*figs. 3, 8*). At the lower extremity of the embryo the cells lose their nuclei, become filled with a dense material, and form a hard capping tissue (*cp, figs. 3, 28, 29*). Distributed irregularly in all parts of the ground tissue are many cells, cavities, and canals filled with mucilage (*m, fig. 8;* black spots in *figs. 28–35*). The cavities are found most abundantly in the cotyledons and are formed by the disorganization of several neighboring cells. The canals, which are formed by the disorganization of the cells end to end, forming tubes of limited length, are most abundant in the petioles of both cotyledons and leaves.

The vascular cylinder is very short, the length being much less than the diameter, and hence it is usually called the vascular plate (*vp*). It is squarish, one diagonal diameter being approximately at right angles to the inner faces of the cotyledons, and the other parallel with them. The xylem (*figs. 32, 33, x*), consisting at this stage probably of protoxylem only, is surrounded by a zone of phloem (*ph*). The xylem is compact and well developed where it borders the phloem, but toward the center it is gradually mixed more and more with pith cells, till in the center the xylem elements lie scattered among the pith cells, these scattered cells being very short and irregular. This condition varies in different specimens, in some the xylem being quite compact to the center, while in others it is entirely wanting in this region (*fig. 32*).

The protoxylem groups.—At each corner of the squarish vascular plate there is a group of protoxylem elements (*px*), which in cross-

section is irregularly oval. These four groups extend downward for a short distance, where they form the protoxylem of the primary root (*a*, *figs. 4, 5, 8*).

The potential vascular tissue.—Above the vascular plate there is a conical or dome-shaped mass of tissue terminating in the growing point of the stem, sharply marked off from cortex and pith, and consisting of long, irregular cells with dense protoplasm and prominent nuclei. The frequent occurrence of mitotic figures shows it to be the most active meristematic region of the stem, being the tissue in which the vascular strands are developed, and therefore the procambium (*pc*, *figs. 8, 34, 35*).

The pith in the vascular plate contains scattered and short xylem elements (*x*, *fig. 8*), as stated above. Above the plate it is conical and terminates in a tier of cells against the epidermis (*pt*, *fig. 8*); in this region the cells are thin-walled and very irregular. In all the pith mucilage cells and cavities are abundant.

The vascular strands.—All the vascular bundles are collateral, except in the upper part of the cotyledons, where they may be regarded as concentric. In the leaf strands the collateral bundle is surrounded by a sheath, which is not well-defined. In the younger strands the few elements are protoxylem, and new elements are added centrifugally (endarch), centripetally (exarch), or in all directions (mesarch). The bulk of the bundle is as yet procambial tissue (compare *figs. 10–15* and *16–21* with *figs. 22–25*). In the older strands it is difficult, if not impossible, to determine where protoxylem ends and metaxylem begins.

The vascular strands of the cotyledons (*figs. 4–6*).—From each of the four protoxylem groups in the vascular plate (*px*) a strand runs outward for a short distance and then branches, the branches separating at wide angles and continuing outwardly in a horizontal plane until well under the bases of the cotyledons, where they turn abruptly upward into the cotyledons, thus giving four strands to each cotyledon, and in such a way that each of the opposite protoxylem groups on the diagonal perpendicular to the inner faces of the cotyledons gives rise to the two inner strands of each of the cotyledons; while each of the other two protoxylem groups gives rise to the outer strands of the cotyledons in opposite edges, that is, one branch goes into the

edge of the cotyledon on one side, and the other branch from the same protoxylem group into the corresponding edge of the other cotyledon. This may be stated in another way. In tracing downward, the four strands of each of the petioles of the cotyledons may be said to join two by two. Just before reaching the central cylinder the inner strands of each fuse, and the outer strands of the one fuse with the outer strands of the other, the four strands thus formed giving rise to the four protoxylem groups. This is shown semidiagrammatically in *figs. 4–6*. Tracing these strands farther upward, they are found to branch once more, so that in the upper part of each cotyledon there may be as many as eight strands; but before reaching the tips of the cotyledons they reunite into one concentric bundle (*fig. 15*), which abuts immediately against the epidermis, thus coming into very close contact with the gametophyte. At this place the tissue of the gametophyte is so closely attached to that of the cotyledons that it is difficult to separate them.

The vascular strands of the leaf primordia.—For each leaf or leaf primordium four strands leave the vascular cylinder or vascular plate, at points not definitely located, but quite well distributed, and generally in such a way that approximately one strand for each leaf or primordium leaves on each side of the squarish central vascular cylinder; also those strands belonging to the first leaves have their origin either in the neighborhood of or in the protoxylem groups of the plate. Two strands leave the cylinder approximately on the same side as that on which the leaf for which they are destined is located, and run more or less directly through the cortex into the ventral part of the petiole without further branching; while the other two strands leave the central cylinder approximately on the opposite side and describe a curve around it (the one in one direction and the other in the opposite direction) through the cortex, through the sheathing leaf base, and finally into the dorsal or adaxial part of the petiole, where they branch and rebranch (*figs. 4–6*). It should be emphasized that the point of origin is not at all definite, and that any particular girdle does not describe an arc of any definite extent, but that the length of the arc depends upon the place of origin of the girdle and the position of the leaf to which it belongs.

It has been said that that edge of the leaf base toward which the

spiral turns is more slender and folds over the next inner leaf more than does its mate (*fig. 7*). It will be observed that the girdle which is destined for that side of the leaf generally describes a longer curve through the cortex than the one destined for the other side. The phenomenon of girdling will become clearer when illustrated by a specific case. In *fig. 6*, taken from a young seedling, L_1, L_2, L_3, and L_4 represent the first, second, third, and fourth leaves or primordia; L_1^1, L_1^2, L_1^3, L_1^4, the four strands of the first leaf; L_2^1, L_2^2, L_2^3, L_2^4, the strands of the second primordium. L_1^1 is the longest girdle of the first leaf and has its origin at the protoxylem group px^1, on the side directly opposite the leaf to which it belongs, ascends for a short distance, then turns outwardly into the cortex and describes a wide horizontal curve, enters the longer and more slender edge of the leaf base, and ascends in the petiole in the dorsal left-hand portion, branching repeatedly in its further course. Trace L_1^4 leaves the central cylinder near the protoxylem group px^4, ascends a short distance, runs upwardly and outwardly into the cortex, describes a horizontal curve in the opposite direction, enters that side of the leaf having the shorter sheathing base, and ascends in the dorsal or adaxial portion of the petiole, where it branches repeatedly in its further upward course. From this it will be seen that the leaf trace L_1^1 pursues a longer course than trace L_1^4. Trace L_1^2 has its origin near the protoxylem group px^3, to the left, ascends for a short distance, runs out into the cortex, makes a very slight horizontal curve (almost direct) into the leaf base, running outwardly, and then ascends on the ventral or abaxial left-hand portion of the petiole without further branching. Trace L_1^3 has its origin near the protoxylem group px^4, ascends for a short distance, runs outwardly (gradually ascending) with a slight curve into the leaf base, and finally ascends in the ventral or abaxial right-hand portion of the petiole without further branching. It will be seen that in the case of the two inner strands L_1^3 makes a girdle of about 90°, while trace L_1^2 is approximately direct.

About the same condition occurs in the traces of the second leaf. Trace L_2^1 has its origin to the left and near the protoxylem group px^3, ascends vertically for a short distance (but farther than the strands of L_1), runs a short distance outwardly into the cortex and then makes a wide horizontal sweep, enters the leaf base on that side

which ensheaths the younger primordium with its more slender edge, ascends in the petioles on the inner or dorsal portion, and branches repeatedly. Trace L_1 has its origin near and to the right of the protoxylem group px^2, describes a girdle of approximately the same magnitude as girdle L_1^4, and runs into the base of the leaf on the right hand. Traces L_2^2 and L_2^3 have their origin respectively on the right and left of the protoxylem group px^1 (quite close to it), and after ascending for a short distance run directly into the outer or ventral portion of the leaf, where they ascend without further branching.

These facts seem to indicate that there is some relationship between the protoxylem groups of the vascular plate and the origin of the trace of the first leaves. The traces of the third leaf (L_3) are followed with some difficulty, but the same condition noted for the first and second leaves is clear. When a fourth leaf is far enough advanced, exactly the same conditions are also presented. The girdling habit of the very young strands is already marked out; but their origin appears no longer to be restricted to the neighborhood of the protoxylem groups, but may occur anywhere in the plate, from which they now ascend vertically for a longer distance before turning out into the cortex. It is very difficult, however, to follow the younger strands while they are still in the potential vascular tissue, since no xylem elements have as yet been formed; but in their passage through the cortex into the primordium their path may be made out clearly, and it shows that the girdle is already established at this stage. Even in the absence of xylem elements, the bundle is clearly marked off by the character and arrangement of its cells (*figs. 26, 27*).

Although the specific case described represents the general state of affairs, many variations are found in the place of origin of the traces. Of the many specimens examined probably no two traces were found to be exactly alike in this respect; also anastomoses between adjoining traces were found here and there. The strands thus ascending vertically for a short distance into the procambial tissue above the vascular plate are the first to assume specific characters. Although the young cylinder is made up of separate traces, it must be observed that these are in the procambial tissue, which is very different from that which surrounds the procambium.

The transition from endarch to exarch xylem.—When a cotyle-

donary strand leaves the vascular cylinder it is endarch (*fig. 10*). As it passes upward and outward, the protoxylem elements recede from the endarch position and are buried more and more in metaxylem, that is, centripetal wood has appeared. When well up in the tubular portion of the petioles of the cotyledons, the protoxylem is surrounded equally on all sides by metaxylem, the xylem being typically mesarch (*figs. 11–13*). From this point on the protoxylem approaches more and more an exarch position, but the xylem does not become completely exarch. Before the end of the bundle has been reached it has become quite concentric, and it becomes very difficult to determine which element was the first to appear (*fig. 15*). Where the bundle leaves the central cylinder the total xylem elements so far as developed are at the innermost part of the bundle, and as the bundle is traced upward they recede from that position and occupy one farther inward, until in the upper extremity of the cotyledon they occupy a position central to the whole bundle. Thus the transposition of the total xylem holds the same relation to the procambium as the protoxylem holds to the metaxylem (*fig. 9, a*).

The leaf traces also when leaving the vascular cylinder are endarch (*fig. 16*), and in passing outward and upward the protoxylem elements recede from the inner edge and are buried deeper and deeper in the metaxylem; and well up in the leaf bases the xylem has become mesarch (*figs. 18, 19*). Afterward the protoxylem approaches more and more an exarch position, until at the transition between petiole and leaf base the xylem has become completely exarch, with the protoxylem lying immediately against the procambium (*figs. 20, 21*). There is at this stage no centrifugal wood above this point; and there is no secondary wood anywhere. The transition may be said to occur, therefore, between the central cylinder and the leaf base, from which point upward the strands are all exarch. It must be taken into consideration that none of the leaves are as yet fully developed, only the first leaf showing plainly the different regions (*fig. 3*). *Fig. 9, a* represents the situation diagrammatically.

It will be observed that only a very small part of the procambium has been developed into xylem tissue in the whole length of the petioles (*figs. 16, 17*). Cross-sections of foliar strands at a low region show, besides the protoxylem and centrifugal metaxylem elements, a pro-

cambium stretching more than half-way across the bundle, the boundary being marked by a thicker-walled tissue, the protophloem. Higher up in the bundle the centrifugal procambium decreases proportionally as the protoxylem moves outward. *Figs. 4, a* and *21* show the situation more clearly; both are taken from very young primordia, the latter much younger and higher up than the former. In *fig. 21* the xylem elements are approximately in the center of the bundle, but there is still considerable procambium between them and the protophloem. The cambium appears to be developed later, just inside the protophloem, and develops tissue actively toward the phloem side only.

THE SEEDLING

EXTERNAL STRUCTURE.—When the seed of Dioon germinates, the hypocotyl pushes through the micropylar end of the seed, where there is at this time an area in the testa, about the diameter of the embryo, which softens readily and is easily penetrated by water. If left to itself, this process takes from a week to a month, and sometimes longer; but if the area referred to is cut away, the hypocotyl pushes through in a few days. During germination the whole of the hypocotyl and the lower part of the cotyledons lengthen.

As soon as the hypocotyl reaches the soil a tap root is sent deep into the ground, and before any leaves appear the root may have penetrated the soil 8 to 12^{cm}, and the diameter of the hypocotyl may have increased to about 1^{cm}. After a long period (which in the greenhouse was about four weeks in case the micropylar end was cut away, but many months if it was not) the first leaf appears between the cleft of the cotyledons, in direct continuation of the axis. As the natural position of the seed during germination is horizontal, and the hypocotyl bends down approximately at right angles, the leaf pushes forth where the cotyledons make a sharp bend. The cotyledons remain in the seed, and in seedlings three or four years old the seed may be seen still attached to the plant. At this time also lateral roots appear in four rows along the primary root, corresponding to the four protoxylem groups.

A second leaf does not appear until perhaps a year later, and about another year elapses before a third appears. A plant of this

age has developed about nine or ten leaf primordia, but only about one-third have developed into leaves.

INTERNAL STRUCTURE.—During germination, in connection with the development of the primary root, not all of the tissue of the tip of the plantlet resumes growth, but only the plerome and a limited portion of the periblem or cortex surrounding it becomes meristematic and pushes through the hard and caplike tissue at the tip of the embryo. The cortex which does not resume growth, as well as the caplike tissue, frays off (*fig. 9, fr*). Also, as growth progresses, the outer layers of the newly formed root, some distance back of the root tip, keeps on fraying off; and underneath a phellogen soon appears and a layer of cork several cells thick is formed. Along each of the four protoxylem strands of the root, continuous from the vascular plate, lateral roots have their origin at definite intervals, being arranged in four rows. Certain cells among and near the protoxylem elements become meristematic, and form the tip of the lateral root, which pushes through the cortex.

The vascular cylinder increases in dimensions uniformly with the growth of the seedling as a whole. New bundles are inserted as new leaf primordia appear, and gradually fill in more and more the vacant spaces between the original strands, so that immediately above the original plate the vascular cylinder is quite compact, while beyond this it continues to be represented by separated strands in the potential vascular tissue.

The vascular strands of the cotyledons.—Not much need be added to the statements in reference to the cotyledonary strands. The transition from endarch to exarch xylem is very much more gradual and the mesarch stage is located relatively much farther up. This is due to the fact that most of the growth of the cotyledon in length occurs at its lower extremity. No secondary wood is developed in cotyledons. The phloem also has increased in bulk, but mature sieve tubes are never developed.

The leaves and scales.—As said above, not all the primordia develop into leaves, most of them remaining abortive and forming scales. Although about one-third of the primordia develop leaves, it does not follow that every third primordium becomes a leaf in regular succession. It sometimes happens that two leaves are developed from

consecutive primordia. Evidences indicate that a scale is not predetermined, but remains abortive through some variable cause. The primordia, whether developing scales or leaves, show the same structure in every particular.

The leaf traces.—The course of the leaf traces in the seedling are the same in general plan as those described for the embryo, but the girdling in the older leaves and scales is much more marked. The internal growth and the appearance of new organs has crowded the older parts farther and farther outward. The circumference of the cortex has increased materially, and also the length of the vascular strands running through it. In the older scales and fully developed leaves these are all of about the same extent, and almost horizontal; but from these, through the younger leaves and scales to the youngest primordia, the sweep of the girdle diminishes; but the girdles are already established in the very youngest of the primordia (*figs. 34, 35, ltg.*)

Although in the strands of the youngest leaf primordia no xylem elements are present, the courses of the bundles may be made out readily because of the arrangement, the staining qualities, and shape of the cells, which have denser protoplasm and larger nuclei, and are longer than the adjacent cells (*figs. 26, 27*). The strands of the very youngest primordia which have their origin on the opposite side of the central cylinder show the girdling habit in the same manner as those of the older leaves, but on a smaller scale. The girdle does not always take the horizontal direction, but may be more oblique at the beginning (*figs. 4, 5, 34, 35*). *Fig. 35* shows this clearly, in which *pc* is the procambium and *ltg*^{1} the girdle of the youngest primordium. So long as such a strand is outside of the procambium it can be followed easily, but is lost after it has entered it.

In the oldest plant examined (three or four years old), the first, second, third, and fourth leaves displayed exactly the same condition as was shown in the young leaves of the embryo and seedling. But in the older leaves, outside of these, it is impossible to determine whether the described order is retained, because of the difficulty in following up strands of such size; but it is certain that anastomoses are more frequent, due to the close proximity of crossing bundles.

The transition of the xylem.—The strands of the older leaves have

a larger development of metaxylem; also secondary wood may have developed in the lower extremities, so that the transition from endarch to exarch has become more prominent and can be made out with greater clearness. The secondary wood accompanies the bundle as yet only for a short distance, and ceases long before the transition from endarch to exarch is complete. As the secondary xylem and centrifugal metaxylem diminish, the centripetal xylem (which of course is all primary) increases in bulk (*fig. 9, a*). In a plant three years old no other secondary wood was present (*figs. 22, 23*). Even in the oldest leaves of quite old plants the secondary wood, which at the origin of the strand is quite massive, decreases very rapidly, and in the petiole just above the leaf base has thinned out to a few elements (*fig. 24*), remaining quite uniform to the rachis, where it disappears still more; while in the pinna no secondary wood whatever is present, all the xylem being primary and centripetal. Although in the transition region the secondary wood diminishes in the same ratio in which the primary wood increases, it must be noticed that the centrifugal wood is not restricted to the secondary wood alone, as was shown in the younger bundles of the embryo, where the transition is clearly carried out in the protoxylem and metaxylem alone. Thus in the seedlings the transition from centrifugal to centripetal wood is carried on after the appearance of secondary wood, and is completed in the primary wood.

In the older strands where secondary wood has been developed, a considerable amount of the centrifugal wood therefore is metaxylem. This is shown by the amount of procambium that has been developed into centrifugal xylem; as may be seen by comparing the younger strands in *figs. 21, 4, a*, for example, where there is a certain amount of centrifugal procambium, the amount depending upon the distance from the point of egress from the central cylinder, with the older strands in *fig. 24*. Sometimes all of the centrifugal procambium has become xylem; more often, however, patches of procambium or isolated cells of it are never lignified and retain their nuclei, and are then referred to as the thin-walled cells. These thin-walled cells do not necessarily lie against the secondary wood, though they most often do, and become most evident in the upper extremities of the transition. A series of cross-

sections of a maturer leaf of a seedling clearly shows the transition from endarch, through mesarch, to exarch, and shows that it is quite independent of secondary wood. The transition begins at the point where the strand leaves the central cylinder, and in the seedling progresses uniformly and is completed in the petiole; but in the old plant the larger proportion of the transition is completed in the lower part of the petiole, where only a few strands of secondary xylem remain and continue uniform until the bundles enter the pinna, when the transition is completed (*fig. 25*).

The cause of girdling.—No particular cause has been assigned for this phenomenon. If such a leaf primordium as is represented in *figs. 3, L_2,* and *8, L,* be selected, it is possible by careful staining to detect four strands which are ultimately developed into vascular bundles. The outer (abaxial) ones pursue a more or less direct course, but in following them from the stem up, their course at first, after leaving the procambium, is vertical; but in the base of the primordium they turn inward to a considerable extent (*fig. 3, L_2*). The two inner or adaxial strands after leaving the procambial cone pursue quite a vertical course, but on reaching a region at the level of the base of the primordium, they begin to turn toward it, one on each side, in some cases ascending rather obliquely, but generally horizontal from the start. *Figs. 34, 35, ltg^1* shows the girdling of quite a young primordium, the youngest one in that specimen. It is plain, therefore, that the girdle is established very early in the development of the leaf to which it belongs.

Tracheae.—In examining older plants, the oldest one being three or four years old, a singular phenomenon is noticed. Between the various bundles of the stem, which at this time do not yet make a complete ring, vertical connections are found, consisting of irregular, reticulated elements, branching and anastomosing, but forming continuous vessels. In the upper part of the plant, where they are developing, long and narrow cells are found winding and crowding through between the parenchymatous cells. A little farther down in older parts of the stem, these cells are found to be multinucleate, with only here and there an ill-defined cross-wall. A little farther down still the nuclei disappear, and soon lignification appears, developing finally into well-defined reticulated tracheae. These wind in a very tortuous

way vertically through the parenchymatous cells from one bundle to another. They are in all senses true reticulated vessels, without cross-walls, establishing a connection between the bundles of the vascular system.

Discussion

In the embryo of *Dioon edule* the vascular cylinder is a protostele, which in some specimens contains a solid xylem mass. From this solid cylinder all gradations are found to the siphonostele. The cells of the pith are actively meristematic, as shown by the mitotic figures, and often in older specimens xylem elements are found in the central part at the level of the vascular plate. The xylem cylinder also continually increases in size, new elements being added to it constantly between bundles already existing, as well as by the cambium.

It should be emphasized that the vascular cylinder in the embryo and seedling does not consist of the short xylem cylinder only, but is continuous in a tissue, very different from the cortex outside and the pith within, which gives rise to strands of procambial tissue running into the leaf primordia. The pith is also a well-defined tissue from the vascular plate to the stem tip, and nowhere suggests that it arises from an intrusion of the cortex through the leaf gaps. An inspection of *fig. 8* shows that it has its beginning at the very tip of the growing point, where it is seen to consist of a single row of cells or a tier of a few cells, gradually expanding as the stem grows into the large pith found in the older part.

The transition of the protoxylem from the endarch to the exarch position was first described by METTENIUS (**4**), who also suggested the descriptive terms centripetal and centrifugal xylem. The situation was interpreted by BERTRAND and RENAULT (**5**), who also established that the centripetal wood is in the same relative position throughout its whole length; that it increases in bulk toward its upper end; and that the centrifugal elements are reduced more and more. They say that the centripetal wood is intercalated between the pole and the outer face. It is regarded as the primary wood (developed from the procambium), while the centrifugal wood is regarded as secondary (developed from the cambium).

The present investigation shows that this statement needs modification. While all centripetal wood is primary, all primary wood is

not centripetal, as one would interpret from the treatise cited. It has been shown that the transition from endarch to exarch is carried through in the metaxylem, both centripetal and centrifugal wood occurring long before secondary wood is developed. It is very hard to tell where protoxylem ends and metaxylem begins, and where metaxylem ends and secondary wood begins. The separation of metaxylem from secondary wood by means of the thin-walled parenchymatous cells is not a safe guide in the region of transition, and only becomes well marked above this region, where the separation of secondary from primary wood is well marked by the thin-walled parenchymatous cells, as noted by many authors. The metaxylem above this point gets to be relatively very bulky, while the secondary wood is represented merely by a few elements. These were the few pitted cells which presented to VON MOHL (1) a situation without a counterpart, now known to be the herald of the secondary wood which has gradually crept up into the petiole, a transformation begun in its early ancestry, according to SCOTT, the "new wood" driving out "the old," the former being the only wood present in the higher gymnosperms and angiosperms.

MATTE (6) argues in very much the same way as does METTENIUS, an argument which would hold good if the protoxylem and a large part of the metaxylem were left out of account. MATTE says that the bundles of the cotyledons have centripetal wood throughout, centrifugal wood only below the upper region of the petioles, and centripetal and centrifugal wood equally well developed at the bases of the petioles. In the present investigation it has been pointed out that there is no centripetal wood at first, and that it gradually increases; while the centrifugal wood diminishes in bulk to the upper extremities, where it is less than the centripetal but does not disappear entirely.

MATTE further says that what has been said of the cotyledonary traces applies equally well to the foliar traces, except that there is no trace of centrifugal xylem in the youngest leaves. It can be shown that as soon as there are enough xylem elements to show the direction of development the centrifugal wood is present, but gradually disappears, and the centripetal wood increases in the same ratio, until in the upper extremities there is only centripetal wood. This also agrees with BERTRAND and RENAULT, except that their statement that centripe-

tal wood is primary and centrifugal wood secondary does not hold true, a mistake apparently shared by MATTE. It has been shown that protoxylem and metaxylem may have both centripetal and centrifugal elements. This is very well seen in cross-sections at a low level of a young strand, where only a few xylem elements are developed. In such a section the protoxylem lies against the inner edge of the bundle, and the procambium can be seen to occupy considerably more than half of the bundle; the boundary of the procambium and the protophloem is distinctly recognizable, the protophloem forming only about one-third of the bundle. In the upper extremities of the petiole, also, there may be seen at an early stage a considerable amount of procambium outside the protoxylem; as these usually fail to develop xylem, thin-walled cells occur between the primary and secondary wood in the upper extremities (*fig. 21*).

The girdling habit was first noticed and described by KARSTEN (**2**) in *Zamia muricata*, without, however, giving the definite number of traces. LESTIBOUDOIS (**3**) adds nothing new except that the traces branch and anastomose. METTENIUS (**4**) next misinterpreted the situation, as described in the historical introduction (p. 357).

In the embryo and young seedling, at least, the leaf traces pursue definite and well-defined courses and constitute a definite system. Four traces are invariably found to leave the vascular cylinder for each leaf. A few anastomoses occur here and there, but these are always reducible to four strands. On two occasions only five strands were found in one of the cotyledons. In the older seedlings anastomoses are more abundant, but so far as observed these can be reduced to the system found in the young seedling.

When KARSTEN (**2**) described the girdling habit, he suggested a cause for it in saying that the bundles are formed very early in the young leaf, and that the originally narrow curves are later crowded far out by subsequent growth and the appearance of new organs. METTENIUS (**4**) also gives a reason for girdling as follows: "In the developmental stage the traces of the youngest leaves lie in the region of the vegetative point, and at first ascend in an almost perpendicular direction, but during the further growth assume gradually an almost horizontal position, and with subsequent growth are lengthened and

the expanse is increased." MATTE (6) assigns almost exactly the same cause.

A definite cause for the girdling cannot be given at present, for it seems to be deeper seated than at first suspected. The even distribution of the four strands of each leaf in the vascular cylinder appears to be the dominating factor. When the primordium appears on the stem tip, its distance from the potential vascular cylinder is very short, and the same conditions that determine cell division in the development of the leaf, cause the differentiation of cells along certain paths that run from definite points in the procambium to definite places into the developing leaf. After the traces have been started, they continue to develop with the further growth of all the tissues; new organs appear and intercalary growth continues; thus the strands are lengthened more and more and their curves are widened to keep pace with the ever increasing growth of the plant.

Summary

1. The vascular cylinder of the embryo is a protostele, but becomes a siphonostele in the seedling. It is very short and squarish in cross-section, one of the diagonals of the section being at right angles to the inner faces of the cotyledons, and the other parallel with them. Near each of the four corners is a group of protoxylem cells, the long diameter of whose section extends along the diagonal.

2. The four protoxylem groups extend downward to form the protoxylem of the root.

3. From each protoxylem group a foliar strand runs outward for a short distance and then branches, the branches separating at a wide angle and continuing outward until under the cotyledon, when they ascend it; the result is four strands for each cotyledon. The two protoxylem groups on the diagonal perpendicular to the inner faces of the cotyledons give rise to the two inner strands of each cotyledon; while the two protoxylem groups on the diagonal parallel with the inner faces of the cotyledons give rise to the two outer strands of the cotyledons, that is, one branch runs into the outer edge of the one and the other branch (from the same group) runs into the edge of the other cotyledon (opposite the first).

4. For each leaf or scale four strands leave the vascular cylinder

at points not definitely located but well-distributed; two strands of each organ leave the cylinder approximately on the same side as the leaf for which they are destined, and run more or less directly through the cortex into the central or abaxial part of the petiole without branching; while the other two strands of each organ leave the cylinder approximately on the opposite side and describe a wide curve around it, the one in one direction and the other in the other, and finally ascend in the dorsal or adaxial part of the petiole, branching repeatedly. The girdle on the side toward which the spiral may be said to turn is generally the longer one.

5. When the cotyledonary vascular strands leave the vascular cylinder they are endarch, gradually become mesarch in their upward course, and finally approach the exarch condition.

6. The foliar vascular strands also are endarch at their separation from the vascular cylinder, and in their upward course become mesarch and finally exarch. In the very young leaf this transition extends through the whole base and petiole uniformly; but in the adult leaf it is comparatively rapid through the base up to the lower part of the petiole, where only a few centrifugal elements remain, and which remain uniform until in the rachis, where the transition is completed, so that in the pinna only centripetal xylem is left.

7. In the lower stretches of the foliar strands a considerable amount of the centrifugal wood is primary xylem.

8. In the foliar strands of the embryo and seedling, the xylem tissue, so far as developed, from below upward passes from an inner to a central position in reference to the whole bundle.

9. The girdle is established very early, and is horizontal from the beginning.

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EXPLANATION OF PLATES XXIII–XXIX

PLATE XXIII

FIG. 1.—Embryo in mature seed: *cot*, cotyledon; *sh*, tubular sheath of cotyledons; *st*, stem proper; *r*, hypocotyl; *s*, suspensor.

FIG. 2.—Cross-section of embryo just above stem tip: *cot*, tubular part of colytedons; L_1, first leaf; L_1^1, L_1^2, L_1^3, L_1^4, vascular strands of first leaf; L_2, second leaf; L_2^1, L_2^2, L_2^3, L_2^4, vascular strands of second leaf; L_3, third leaf.

FIG. 3.—Median longitudinal section of lower part of embryo, parallel with inner faces of cotyledons: *cot*, cotyledon; L_1, L_2, first and second leaves; *pn*, pinna; *ls*, foliar strand; *st*, stem tip; *p*, pith; *cs*, cotyledonary strand; *vp*, vascular plate; *pl*, plerome; *cp*, caplike tissue; *sp*, suspensor.

FIG. 4.—Semi-diagrammatic reconstruction of part of vascular system of embryo; *cot*, cotyledon; *tb*, tubular part of cotyledons; *cs*, cotyledonary strands; L_1^1–L_1^4, foliar strands of first leaf; L_2^1–L_2^4, foliar strands of second leaf; *vp*, vascular plate; *a*, protoxylem elements continuing downward into the hypocotyl.

FIG. 4*a*.—Cross-section of a vascular bundle in upper extremity of young leaf; *x*, xylem elements; *a*, cells losing their contents during lignification; *pc*, procambium; *pph*, protophloem; *b*, line showing boundary between protoxylem and protophloem.

PLATE XXIV

FIG. 5.—Semi-diagrammatic reconstruction of part of vascular system of embryo, to show especially the girdling: L_1, L_2, traces of first and second leaves; *vp*, vascular plate; *px*, protoxylem groups; *a*, xylem elements continuing down from protoxylem groups to form the protoxylem of the primary root.

FIG. 6.—Diagram giving bird's-eye view of vascular system, to show origin and girdling of foliar strands: *cot*, tubular part of cotyledons; *cs*, cotyledonary traces, one group for each cotyledon; L_1, L_2, L_3, L_4, first, second, third, and fourth leaves; L_1^1, L_1^2, L_1^3, L_1^4, traces of first leaf; L_2^1, L_2^2, L_2^3, L_2^4, traces of second leaf; *px*, protoxylem groups.

FIG. 7.—Outline of cross-section just above stem tip of seedling three or four years old, to show phyllotaxy; *cot*, cotyledons; *1–8*, leaves in order of age.

FIG. 7*a* (1).—Stem tip from germinating embryo with leaf primordium (*L*) developing on the side.

FIG. 7*a* (2).—Stem tip from rapidly growing seedling, showing growing point (*st*) in the middle and a leaf primordium (*L*) on each side; this section showed numerous spindles in growing point and primordia.

PLATE XXV

FIG. 8.—Details of central region of embryo in median longitudinal section: *L*, youngest leaf; *st*, stem tip; *ep*, epidermis; *pt*, pith terminating in stem tip; *pc*, procambium; *vp*, vascular plate; *ph*, phloem; *a*, continuation of protoxylem into the root; *p*, pith; *pl*, plerome; *m*, mucilage cells.

FIG. 9.—Median longitudinal section of lower part of germinating embryo, showing lengthening of plerome, development of primary root, and fraying-off of epidermis and outer part of cortex (*j*).

FIG. 9*a*.—Diagram to show transition of protoxylem in the metaxylem, and transition of primary xylem from an inner to a central position in a young bundle: *aa'*, inner, and *gg'*, outer limits of bundle; shaded portion (*ab*, *cd*), xylem tissue, *ad*, protoxylem; unshaded portion in *aa'* (*cf*), procambium; *cf* (*gg'*), protophloem; dotted line *cf*, boundary between procambium and protophloem.

PLATE XXVI

FIGS. 10–15.—Series of cross-sections of cotyledonary traces: *fig. 10*, just before joining vascular cylinder; *fig. 15*, after the several bundles have reunited in upper extremity of cotyledon; *px*, protoxylem. ×850.

PLATE XXVII

FIGS. 16–21.—Series of cross-sections of leaf traces: *fig. 16*, just before joining vascular cylinder; *figs. 17–20*, at considerable intervals above each other; *fig. 21*, younger trace; shaded portion protophloem. ×850.

PLATE XXVIII

FIG. 22.—Cross-section at low level of foliar trace of a three-year-old plant: *px*, protoxylem (endarch); *x*, xylem, of which probably the larger portion is centrifugal metaxylem and only a small portion is secondary xylem; *ph*, phloem; *pph*, protophloem. ×425.

FIG. 23.—Section from the same strand as *fig. 22*, but considerably higher up; *px*, protoxylem (mesarch). ×425.

FIG. 24.—Section of bundle from old leaf of quite a large plant just below rachis: *px*, protoxylem (exarch); *mx*, metaxylem (centripetal); *tc*, thin-walled cells; *sx*, secondary xylem; *ph*, phloem; *pph*, protophloem. ×425.

FIG. 25.—Cross-section of bundle in pinna: lettering as in *fig. 24;* note absence of secondary xylem. ×425.

FIG. 26.—Median longitudinal section of very young leaf trace, showing shape and arrangement of cells; shaded portion, earliest procambium. ×1200.

FIG. 27.—Cross-section of the same bundle as in *fig. 26*.

PLATE XXIX

FIG. 28.—Median longitudinal section of embryo at right angles to inner faces of cotyledons. ×11.

FIG. 29.—Median longitudinal section similar to *fig. 28: ct*, cotyledonary traces; *cp*, caplike tissue; *s*, suspensor. ×30.

FIG. 30.—Cross-section of young seedling at region of union of cotyledonary trace with vascular cylinder: *ct*, cotyledonary traces belonging to one cotyledon. ×16.

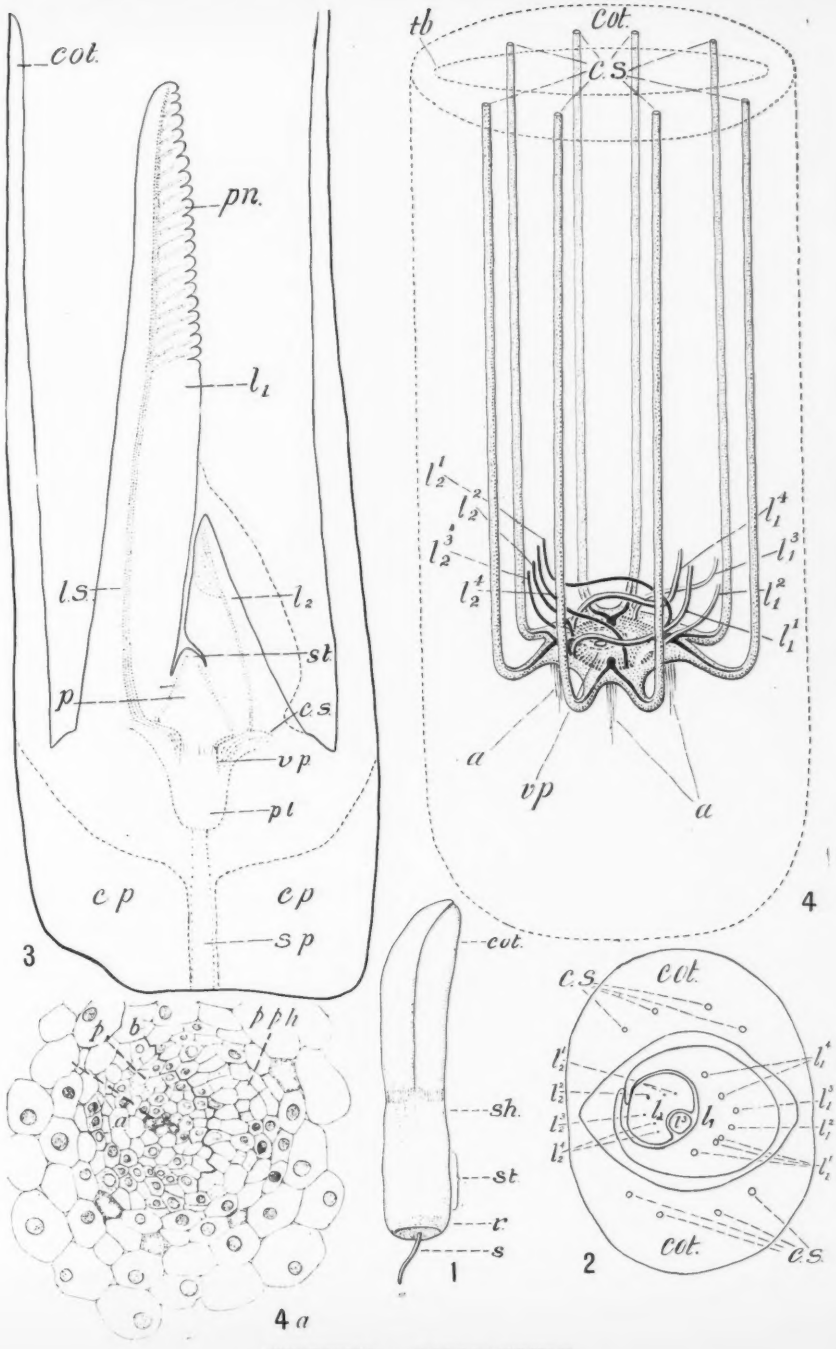
FIG. 31.—Section of same further up to show girdling: L_2^1, outer long girdle; L_2^4, outer shorter girdle; L_2^2, L_2^3, inner girdles; all of second leaf. ×16.

FIGS. 32, 33.—Cross-sections of embryo at region of vascular plate (*vp*); *px*, protoxylem; *x*, xylem; *ph*, phloem; union of cotyledonary traces two by two, and union of resultants with vascular plate at protoxylem groups. ×30.

FIG. 34.—Median longitudinal section of seedling three years old: *pc*, procambium; *ltg*, girdle; *lt*, trace; *lg*, leaf gap. ×30.

FIG. 35.—Cross-section of embryo to show early appearance of girdle; *pc*, procambium; ltg^1, girdle of very young leaf; ltg^2, girdle of next older leaf. ×30.

The black spots in all the photographs are mucilage cavities or cells.



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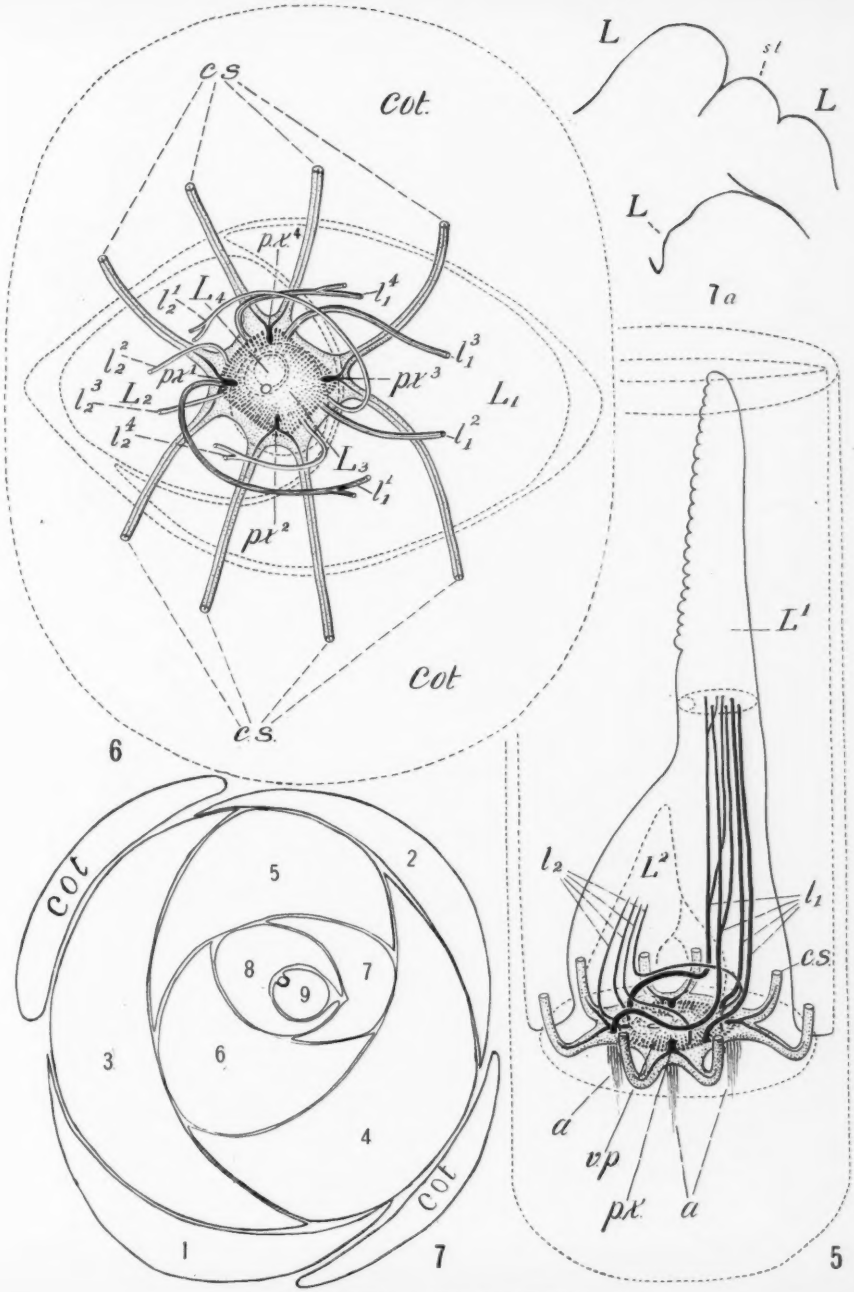

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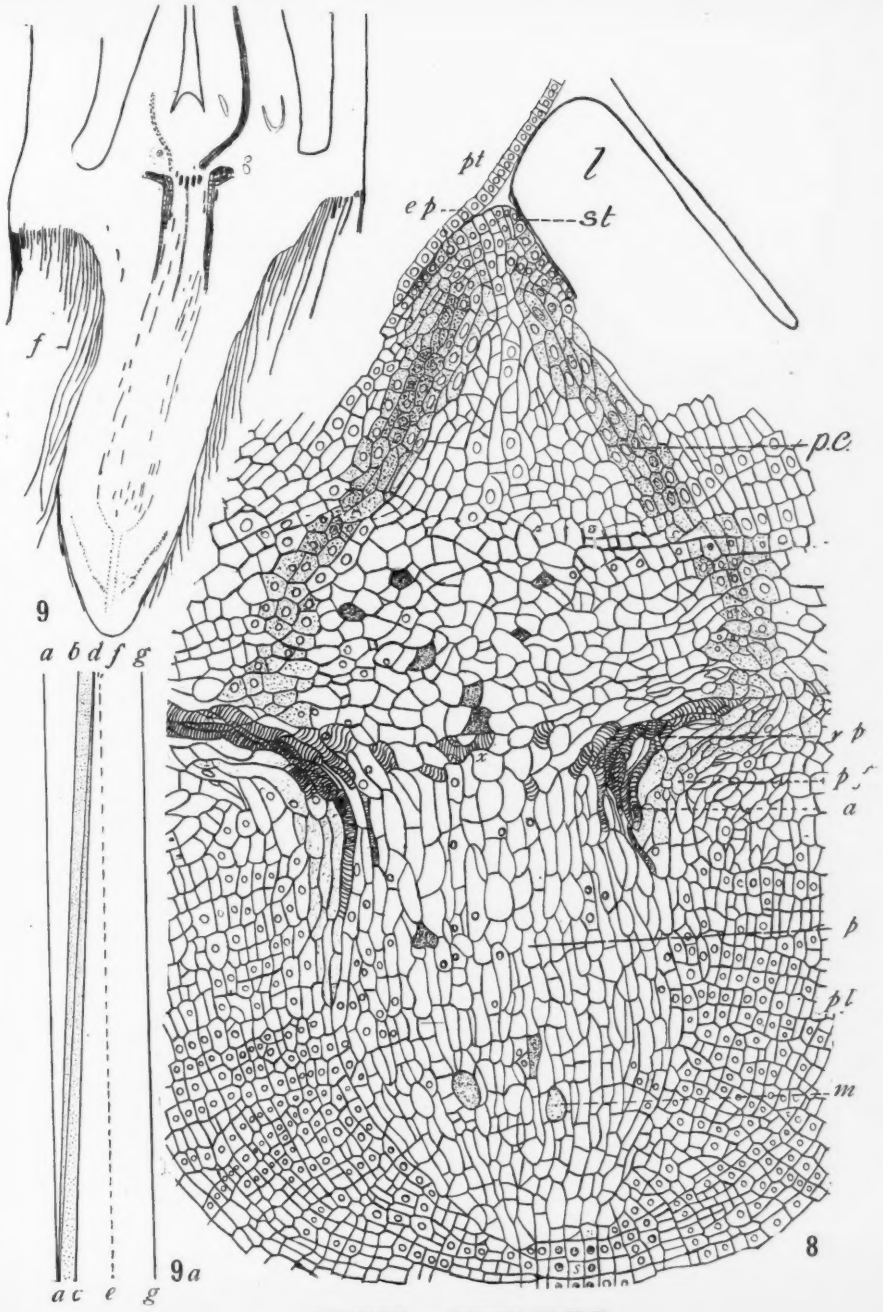

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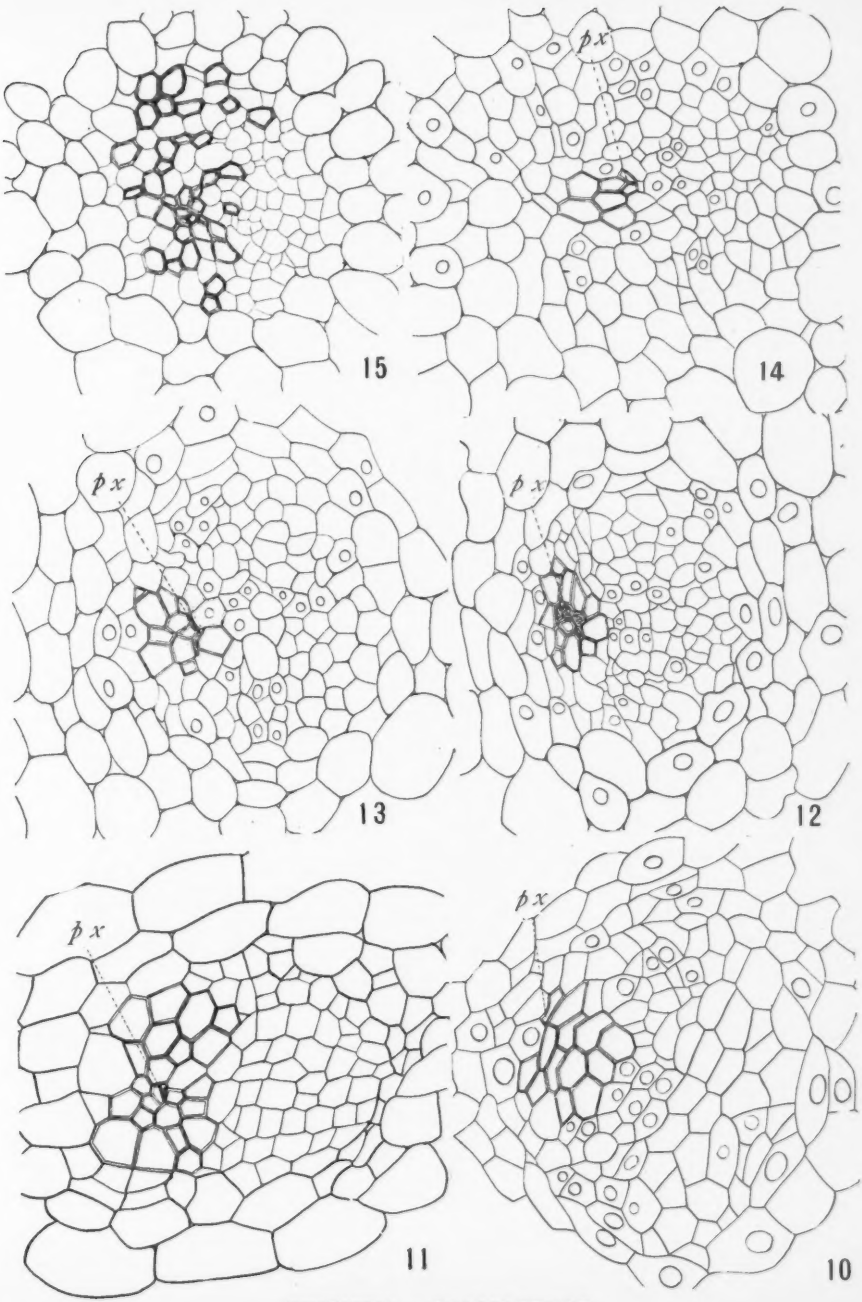

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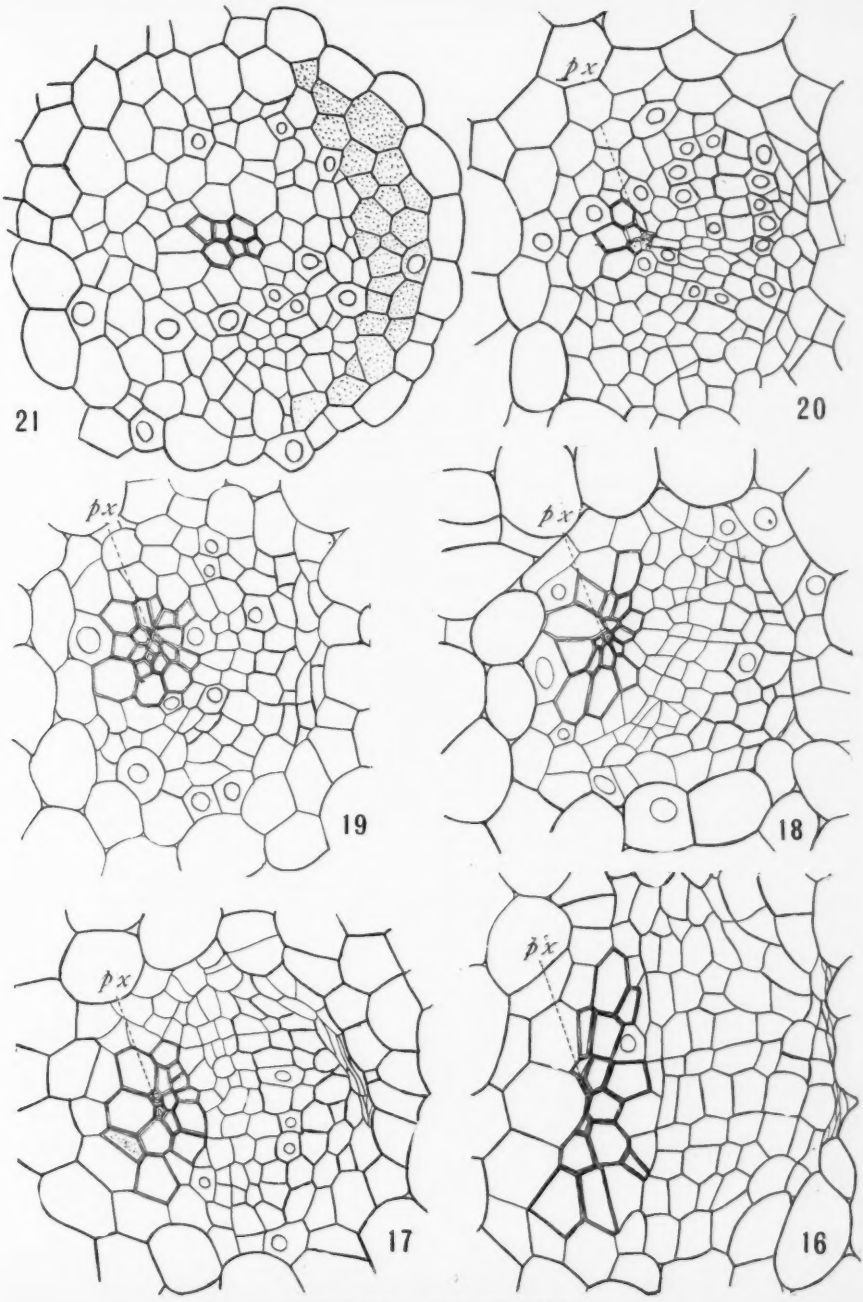

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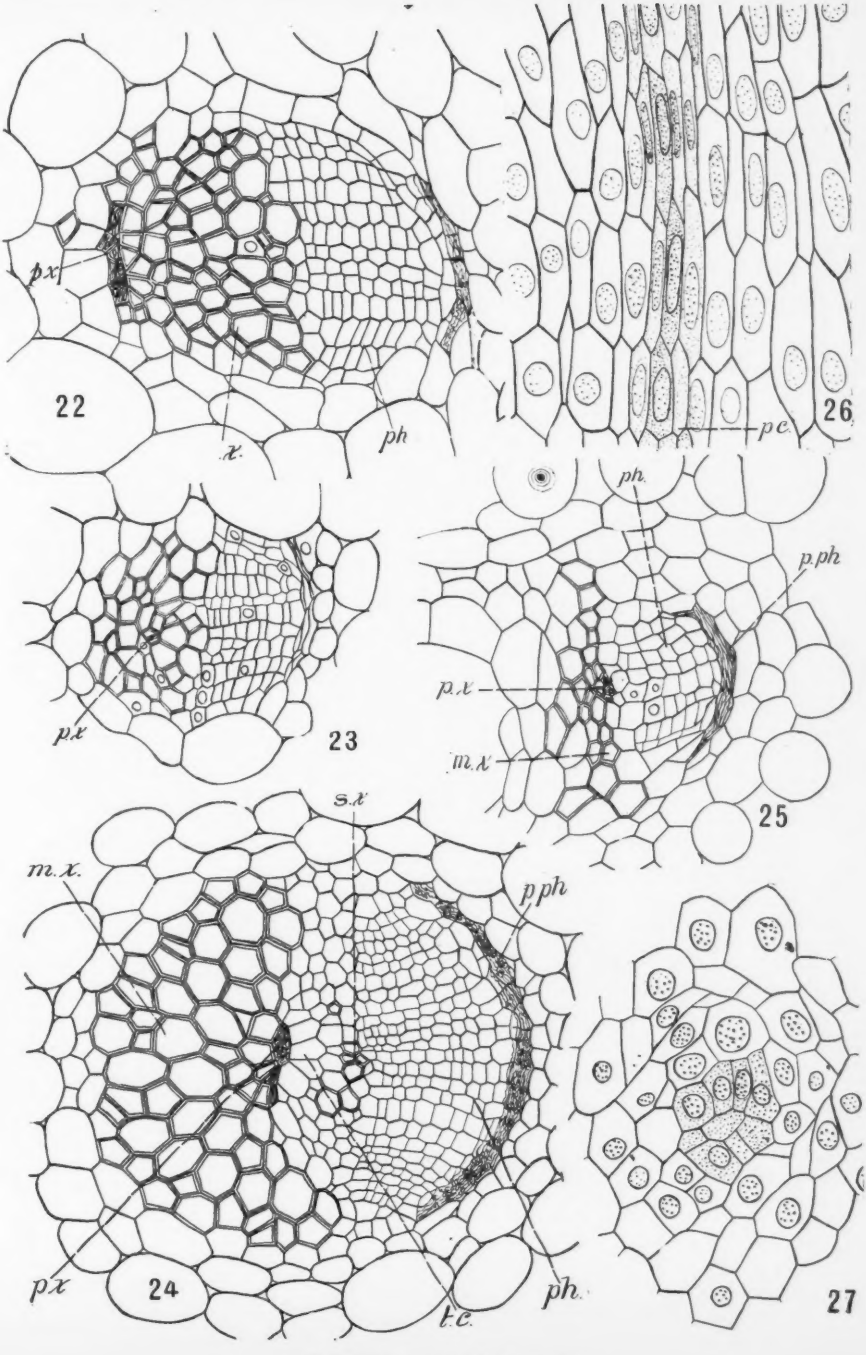

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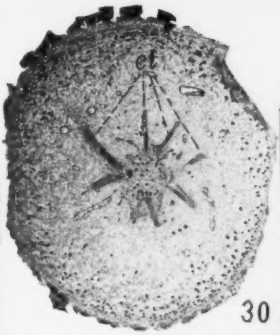

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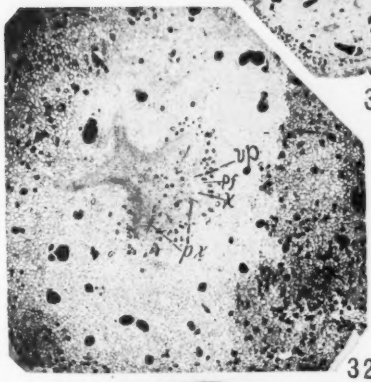

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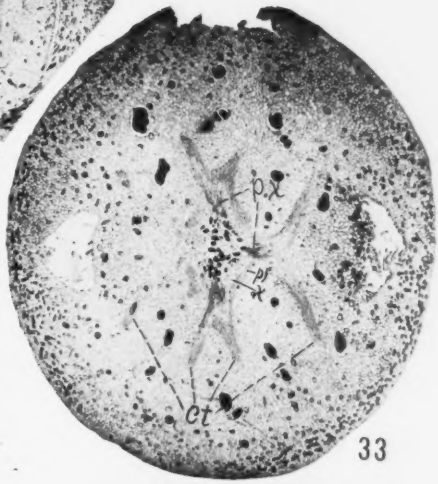

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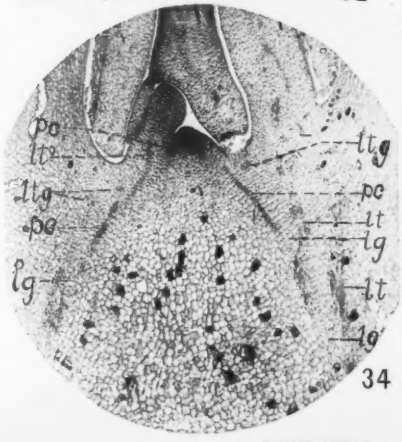

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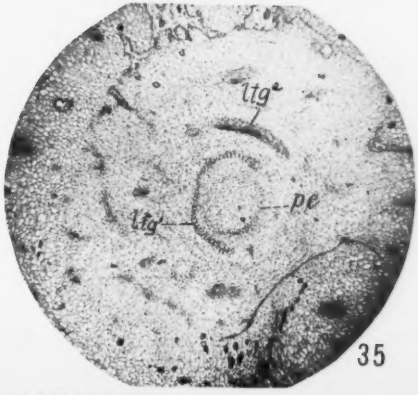

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BRIEFER ARTICLES

NEW COLORADO SPECIES OF CRATAEGUS

(WITH TWO FIGURES)

During the past three years the writer, together with Messrs. G. S. DODDS and W. W. ROBBINS, has been making ecological studies of mesa and gulch plants in the vicinity of Boulder, Colorado. In tracing out the distribution of Crataegus it became apparent that there were present some undescribed species. Full and complete collections were made therefore by Mr. DODDS and the writer during the present season from marked trees, in order that there could be no confusion in regard to the specimens. Very complete notes of abundance, occurrence in different drainage areas, etc., were made. Fruits were preserved in alcohol as well as by drying.

It was expected at the beginning of the study that the new forms would be found to be hybrids between previously described species. This, however, is not the case. The distribution of *C. Doddsii*, in particular, shows that it is a true species. Isolated thickets of *C. Doddsii* have been found as far as five or ten miles away from any trees of other species of Crataegus. Various other considerations which will be noted elsewhere lead to the belief that the Colorado species of Crataegus do not hybridize.

A paper by my colleague, Professor T. D. A. COCKERELL,[1] gives a full account of the species described for Colorado up to the present time. I am much indebted to this paper and to suggestions from its author.

The following species have the characters of TOMENTOSAE of SARGENT and should be placed in that group. The first might almost as well be placed with COCCINEAE.

Crataegus Doddsii, sp. nov.—*Arbor* parva, vel frutex; ramis cineraciis, spinescentibus; ramulis junioribus glabris vel paululum pubescentibus, colore castaneato. *Folia* lucida; glabrata, sed nerviis infra pubescentibus; obovata, saepe ad apicem truncata, margine serrata, et superne obscure lobata. *Petiolus* longe $\frac{1}{4}$–$\frac{1}{2}$ laminae; superne margine angusta glandulosa. *Flores* conspicui; corymbis compositis; pedicellis glabris vel majus minusve pubescentibus; staminibus 10 vel minus; antheris albis. *Fructus* durus, cum pilis raris, late pyriformis; longe 9^{mm}, in longitudinem costatus;

[1] Univ. of Colorado Studies 5:41–45. Dec. 1907.

colore ruber sanguineusve; autumno maturans; nucellis osseis, 2–3.—*Fig. 1.*

Hab. in Colorado, U. S. A.

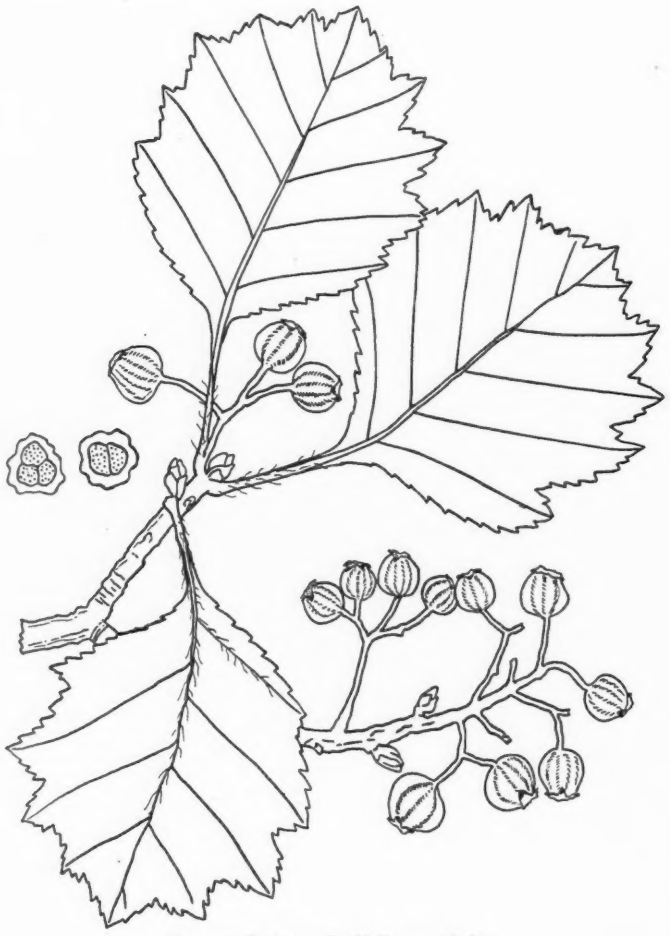

FIG. 1.—*Crataegus Doddsii*, natural size.

This species is nearest related to *C. erythropoda*, from which it differs in having the anthers white (not pink), in having less shiny leaves, in the presence of more

pronounced ridges in the fruit, and in the lighter color of the fruit (that of *C. erythropoda* is mahogany brown).

Type specimen: *Ramaley* and *Dodds* 6181, Pole Canyon near Boulder, Colorado, Sept. 19, 1908. Type in University of Colorado Herbarium; cotype

FIG. 2.—*Crataegus coloradoides*, natural size.

in Rocky Mountain Herbarium, Laramie, Wyoming. Material is at hand from various localities in Boulder County, 5000–8000ft altitude.

Crataegus coloradoides, sp. nov.—*Arbor* parva, vel frutex: ramulis junioribus pubescentibus; ramis spinescentibus. *Folia* supra cyaneo-virida, lucidula, infra glauca; obovata; margine serrata et parve lobata;

nerviis infra pubescentibus. *Petiolus* pubescens, longe ½–½ laminae. *Flores* conspicui; corymbis compositis; pedicellis pubescentibus; staminibus 10 vel minus; antheris albis. *Fructus* autumno maturans; mollis, dulcis, ruber vel puniceus, globosus (9^{mm}), levis non costatus, cum pilis raris; nucellis osseis, 2–3.—*Fig. 2.*

Hab. in Colorado, U. S. A.

This species is nearest to *C. occidentalis* Britt., but has much longer petioles, smaller, shiny leaves, not dull, somewhat smaller fruit, which is globose, not broader than long as in *C. occidentalis*. The tree is also less gnarled and there are no persistent bud-scales at flowering time.

Type specimen: *Ramaley* and *Dodds* 6184, Pole Canyon near Boulder, Colorado, Sept. 19, 1908. Type in University of Colorado Herbarium; cotype in Rocky Mountain Herbarium at Laramie, Wyoming.

The species grows in gulches in the lower foothills from 5500 to 7000^{ft} altitude; mostly about 6000^{ft}.

It may be of interest to students of Crataegus to point out that the fluting of the fruits, as in *C. Doddsii*, is a character which has apparently not been used by other observers. In alcoholic material and in well-dried specimens this character is very noticeable. Attention is called to the cross-section of the fruit shown in the drawing (*fig. 1*).—FRANCIS RAMALEY, *University of Colorado, Boulder, Colorado.*

SEXUAL CONDITION IN FEGATELLA

Until the last few years, nothing has been known in regard to the sexual differentiation in the sporophytic stage of dioecious bryophytes. In connection with a discussion of the germination of the zygotes of certain dioecious molds, the writer[1] first pointed out this lack of knowledge on the subject and raised the question whether a capsule of a dioecious bryophyte contains both male and female spores or spores of but a single sex. The question so far has been settled by the writer[2] for the single hepatic *Marchantia polymorpha*, and by the MARCHALS[3] for the three mosses *Barbula unguiculata*, *Bryum argenteum*, and *Ceratodon purpureus*. In all these forms, as well as in the germinating mold Phycomyces, a single sporangium was found to contain both male and female spores as judged by the thalli they produced when sown in pure cultures.

The purpose of the present brief notice is to add the dioecious hepatic

[1] Zygospore germinations in the Mucorineae. Annales Mycologici **4**:25. 1906.

[2] Differentiation of sex in thallus, gametophyte, and sporophyte. BOT. GAZETTE **42**:161–178. 1906.

[3] Recherches expérimentales sur la sexualité des spores chez les Mousses dioïques. Mém. couronnés Cl. Sc. Ac. Roy. Belgique **2**¹:1–50. 1906.

Fegatella conica to the list of bryophytes already investigated, and to give increased weight to the opinion that the type of sexual differentiation in the forms so far studied is at least the predominant if not the universal type among the bryophytes.

April 22, 1906, Fegatella was found by the writer abundantly fruiting in the large pot holes in the Gletschergarten at Lucerne. The capsules for the most part were not yet opened. Two days later, in the Botanical Laboratory at Halle, unopened sporangia were carefully dissected out, and after a microscopic examination to make certain that no spores from other sporangia had adhered to their outer surfaces, they were preserved separately in small sterile paper envelopes. Spores from one of these single sporangia were sown May 10 in several Petri dishes in 0.1 per cent. Knop's solution. By June 19, the germinations from the spores had grown to sufficient size to be readily handled, and accordingly 128 from a single Petri-dish culture were transplanted to earth in regular rows in large shallow pots. They had reached a considerable size but were not sufficiently matured to produce their sexual organs when it became necessary in the latter part of July to leave them in the care of the *Diener* of the laboratory. The coming November a number of the plants were shipped to the writer packed in parchment paper with damp sphagnum moss. Fegatella does not multiply non-sexually by gemmae as does Marchantia, and there is practically no danger of infection in the earth cultures from thalli of the same species. Of the plants shipped, twelve survived the two weeks' journey and were sown in separate pots in the Harvard Botanic Gardens, where they have since been kept growing. Three of the cultures by the character of the sexual organs produced have shown themselves to be female and eight to be male. A single capsule of Fegatella, therefore, contains both male and female unisexual spores. The other cells of the sporophyte, undoubtedly, are hermaphroditic in character, although attempts to demonstrate this by regenerations from the stalk or wall of the sporangia were entire failures. One of the twelve pots, presumably with only the growth from a single spore, showed both antheridia and archegonia, but it was not possible to find that the lobes producing these different sexual organs were connected. It is possible that the differentiation of sex is not always complete in the capsule of Fegatella, and that hermaphroditic spores are in fact occasionally produced, as is the case in the mold Phycomyces; but it seems more likely that a fragment of a thallus of the other sex became accidentally mixed with the growth planted in this particular pot.—A. F. BLAKESLEE, *Connecticut Agricultural College, Storrs, Conn.*

A NEW CHARACTERIS[illegible] ENGELMANN SPRUCE

In 1907 near Bernice, Mont., the writer obse[illegible]en of Engelmann spruce (*Picea Engelmanni* Engelm.) with resin vesicles [illegible] which are so typical of the genus Abies. [illegible] not mentioned in any of the descriptions of Engelmann spruce, and the character appears to have been entirely overlooked by botanists. It is therefore desired to direct attention to this noteworthy feature and place it on record. Since 1907 it has been observed at several places in Colorado, and is probably found everywhere on this species of spruce. The vesicles or "blisters" are not so abundant or conspicuous as in the genus Abies. In a few instances they were found to be well developed and closely resembled the balsam blisters. Commonly, even when of large size, they were rendered obscure by being deeper in the bark.

The only genus besides Abies previously described as having these vesicles is Pseudotsuga, in which they are less conspicuous than in Abies. To these two genera must now be added at least one species of the genus Picea, which shows this common character in many individuals, though it is rarely prominent.—E. R. HODSON, *Washington, D. C.*

CURRENT LITERATURE

BOOK REVIEWS

The Wiesner [illegible]

As a testimonial of esteem and affection, the friends and [illegible] WIESNER, the distinguished director of the plant-physiological institute of the University of Vienna, prepared for his seventieth birthday (January 20, 1908) a volume[1] containing more than forty papers, which are of course predominantly physiological. Only one is from this country: TRELEASE gives an account of variegation in the Agaveae, with many illustrations. It is only possible to give an idea of the scientific contents by stating most briefly the drift of each paper.

TSCHIRCH opens the volume with a brief sketch of some ideas on the relationships and origins of the resins and gums, as to whose chemistry light is breaking. MOLISCH shows that *Xylaria Hypoxylon*, *X. Cookei*, *Trametes Pini*, *Polyporus sulfureus*, and *Collybia cirrhata* are to be stricken from the list of luminous fungi. STRASBURGER discusses nuclear division in the Characeae, with special reference to the so-called amitosis, which he holds is not a senile process. VON HOHNEL and LITSCHAUER present a synopsis of Austrian Corticeae, including 131 species, of which 5 are new. MÖBIUS figures and describes the siliceous accretions in the stem and leaf cells of the tropical American *Callisia repens* (Commelinaceae). CZAPEK discusses the relation of geotropism to certain features of plant form, especially to the position of branches both of stems and roots. BURGERSTEIN gives a synoptical key to the genera of Coniferae, based on the anatomical characters of the wood. VON PORTHEIM and SAMEC report less dissimilation ("respiration") in seedlings of pea grown in Ca-free solutions than in those grown in Knop's solution. DARWIN shows by various methods that the perceptive region for gravity and light is in the cotyledon of Sorghum, thus disposing of objections that have been raised to this view.

HANAUSEK gives a further account of the "carbon-layer" of the pericarp of certain Compositae. GOEBEL finds the relations of symmetry in a considerable number of flowers and inflorescences examined to be explicable neither by pressure nor purpose, but rather by "nutritive relations" (not more exactly analyzed). RICHTER declares (on results derived from the usual but inconclusive culture methods) that calcium is a necessary food element for a colorless diatom, probably *Nitschia putrida*. SENFT demonstrates the occurrence of physcion and parietin in lichens, and the methods of recognizing them microchemically.

[1] WIESNER-FESTSCHRIFT. Ed. by K. LINSBAUER. 8vo. pp. viii + 548. *pls.* 23. *figs.* 56. Wien: Verlagsbuchhandlung Carl Konegen. 1908. *Kr.* 24, geb. 28.80.

AMBRONN indicates the chemical and physical alterations which the cellulose of textile fibers undergoes when impregnated with zinc sulfid. NESTLER has extended MACDOUGAL'S studies on the skin poison of *Cypripedium spectabile* secreted by the glandular hairs. NĚMEC writes briefly on his experiments upon regeneration with the roots of Taraxacum. STOKLASA declares unequivocally that in anaerobic and in aerobic respiration the formation of lactic acid, alcohol, and CO_2 (and in addition acetic and formic acids in aerobic respiration) is due solely to enzymes. KAMMERER describes a case of symbiosis between *Oedogonium undulatum* and aquatic larvae of *Aeschna cyanea*. GRAFE furnishes an appropriate study of the gum-ferment whose action WIESNER first correctly described.

HEINRICHER adds to his two previous papers on the effect of light upon germination of seeds a general discussion of the subject, with some new experiments and a valuable summary. MIKOSCH finds that the scion of Epiphyllum grafted upon Peireskia as a stock, exercises a definite effect in giving rise in its cells to the bodies peculiar to Epiphyllum. FIGDOR reports exact determinations of the phototropic sensitiveness of certain plants in relation to the zone of indifference (which seems not to exist in some). KOORDERS again describes and figures his Javanese genus *Wiesneromyces*. ZIKES has a further account of his *Bacterium polychromicum* and its pigment production. VON WETTSTEIN observed a saltatory rise of the fertility (at first small or none) of the pollen in two undoubted bastards of Sempervivum, and suggests that here may be an important factor in the origin of new forms. VON WEINZIRL contributes data on the mechanical functions of the various organs of the embryo of cereals in their escape from investing structures. K. LINSBAUER reports propagation of the excitation in the primary petiole of Mimosa at a rate of $100^{mm\text{-}sec}$, and a reaction time averaging 0.09 to 0.35^{sec}, with minimum 0.07 and maximum 0.80^{sec}.

FRITSCH describes cystoliths of *Klugia zeylanica*. RACIBORSKI recognizes in *Coreopsis tinctoria prolifica* "an undoubted mutation." L. LINSBAUER gives an account of "photochemical induction" in the formation of anthocyan in the etiolated seedlings of buckwheat. KRASSER makes a critical synopsis of the lower Lias flora of the Austrian Alps. SCHIFFNER presents an ecological study of so-called *Knieholzwiesen* of the Iser Mountains. WEGSCHNEIDER states that the fats are really saponified by stages and the reaction is only apparently bimolecular. SKRAUP writes briefly on the leucin of proteins. STROHMER gives an account of the accumulation and migration of saccharose in the sugar beet. KARZEL shows some interesting peculiarities in the lignification and cutinization of the walls of the stomata in cycads. PRZIBRAM notes the renewed growth from stumps of red wood, familiar to Californians. WILHELM figures a remarkable distortion of the tips of a fir. LOPRIORE writes on twin-roots in Zea and Vicia.

Besides the papers listed, there are several on more general topics, historical or philosophical, that are omitted for lack of space. The volume is a worthy memorial and gives evidence of the inspirational force of a great investigator.—C. R. B.

MINOR NOTICES

Botany and Pharmacognosy.—A third edition of KRAEMER'S *Textbook*[2] has appeared with great promptness after the publication of the second.[3] The changes made have to do chiefly with the illustrations, fifty unsatisfactory halftones being replaced by line drawings, and several new illustrations being introduced, especially of solanaceous drugs and plants.—J. M. C.

NOTES FOR STUDENTS

Chlorophyll and assimilation.—LUBIMENKO, who has been devoting his attention to the influence of light upon various processes, has endeavored to solve these questions: Is the intensity most favorable for the decomposition of H_2CO_3 likewise the most favorable for the production of dry matter? What is the optimum illumination which will produce the most dry matter in different green plants? How is this optimum related to the various quantity of chlorophyll in the leaves? He reports[4] that the production of dry matter is determined by the light energy absorbed, which in turn varies with the illumination and the quantity of chlorophyll in the leaves. The latter is not constant, but varies with the illumination. In nature the minimal quantity of chlorophyll in all species studied corresponds to the normal daylight undiminished. As the light is weakened the quantity is rapidly increased until it attains a maximum; then it diminishes with still weaker light. In any species the maximum is reached with weaker light as the temperature rises. As to this matter, two classes of plants may be distinguished: those that produce little chlorophyll, whatever the external conditions, and those that accumulate a good deal. In the former the quantitative variations in chlorophyll due to illumination and temperature are smaller than in the latter, which also for the production of a maximum quantity require a more feeble light than the former. In general the maximum of pigment corresponds to a light sensibly weaker than that required for a maximal production of dry matter. From which it would appear that light, as inferred for other reasons, has a special action in the formation of chlorophyll.

The production of dry matter increases with the light absorbed, up to a maximum, then diminishes. This optimal light is constant with the same species at constant temperature, but diminishes as the latter increases. [This indicates that the energy optimum is a constant.] The optimal intensity for the production of dry matter varies according to the quantity of chlorophyll, augmenting as the pigment diminishes, and *vice versa*. In nature the maximal production in plants poor in chlorophyll corresponds to the normal daylight, but in those

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[2] KRAEMER, HENRY, A textbook of botany and pharmacognosy. Third edition. pp. viii + 850. *figs. 328*. Philadelphia and London: J. B. Lippincott Co. 1908.

[3] Reviewed in BOT. GAZETTE **46**:231. 1908.

[4] LUBIMENKO, W., Production de la substance sèche et de la chlorophylle chez les végétaux supérieures aux différents intensités lumineuses. Ann. Sci. Nat. Bot. IX. 7:321–415. 1908.

rich in pigment it corresponds to a greatly weakened light. In general the development of the plant is proportional to the dry matter produced; but growth is not exactly proportional thereto, for it is more feeble in strong light and more vigorous in weak light than it would seem if it were measured by the augmentation of the dry weight. The root and stem are unequally affected; the former grows more and the latter less as the illumination increases; but too strong a light reduces the rate of growth of both because less food is produced. The development of the leaf blades generally increases to a maximum with decreasing light, but diminishes with further enfeeblement. With some exceptions transpiration does not have any sensible effect on the total production of dry matter, though the quantity in proportion to the fresh weight generally diminishes with the diminished light.

All the green plants are capable of regulating the quantity of light absorbed, and so partly avoiding the injurious effect on production of dry matter, by altering the quantity of chlorophyll produced. These adaptations are limited in plants poor in chlorophyll; but those rich in pigment can adjust themselves to a relatively very weak illumination. Biologically the massing of plants ought to be an advantage by reducing the illumination. Physiologically the action of light is not limited to the reduction of H_2CO_3, for it affects also the speed of incorporation [assimilation] of carbohydrates. The former demands a stronger light than the latter, for which there is an optimum, and below and above this it rapidly diminishes in rate. It is by this retarding action of bright light upon the incorporation of carbohydrates and a consequent considerable accumulation of foods in the green tissues that the diminution in the production of dry matter is explicable when the illumination passes a certain limit. [This explanation does not explain and surely needs further consideration.] If the chemical transformations which constitute the incorporation of carbohydrates are of enzymic nature, it is probable that they are affected by the action of light on the formation and destruction of enzymes. [Is not the fate of the greater part of the carbohydrates to be sought rather in protein synthesis than in "incorporation;" and is there any evidence of enzymic action in this process?]—C. R. B.

Self-digestion and endospermic respiration.—The long effort to settle the question of the vitality of the endosperm, which was begun by GRIS and VAN TIEGHEM, was practically abandoned after the culminating researches of BROWN and ESCOMBE, PURIEWITSCH, and BROWN and MORRIS. Since that time very little indeed has been contributed to the subject. Perhaps one reason was that the results of somewhat related investigations so modified our knowledge of enzymes and respiration that self-digestion as a test of vitality was no longer regarded as valid. Altogether disregarding such opinions, BRUSCHI[5] takes up the problem practically as it was first attractive fifty years ago, "to solve the

[5] BRUSCHI, DIANA, Researches on the vitality and self-digestion of the endosperm of some Graminaceae. Annals of Botany **22**:449–463. 1908.

question whether the reserve material contained in the endosperm of amyliferous seeds is exclusively digested by enzymes secreted during germination, or whether the endosperm cells renew their vital activity and themselves dissolve their own food material."

The endosperms of maize, wheat, rye, and barley were tested. The seeds were allowed to soak 48 hours before removal of the embryo and scutellum in some instances, and in the other tests no statement is made on this point. No controls are mentioned; in fact the experimental data are so meager that the reader is compelled to reject the results simply because the author leaves him too ignorant to judge. In the digestion tests no controls are mentioned. The simple statement that aseptic conditions were maintained is altogether insufficient. We read that chloroform water was used, but whether it was saturated or half saturated or something else the reader cannot know. The general trend of the conclusions is that all of the endosperms mentioned are more or less capable of self-digestion, and that such activity is independent of vitality. The endosperm of rye is pronounced dead, but in maize, barley, and wheat there is more or less vitality in some of the amyliferous cells.

STOWARD[6] has found that the pure endosperms of Hordeum and Zea under appropriate conditions manifest a gaseous exchange of respiratory character. He also regards similar behavior on the part of the aleurone layer as strengthening the evidence that the cells of that tissue possess vitality. The paper is presumably an initial effort, because (*a*) the introduction as such is unnecessarily tedious, and as a digest of the literature is deficient in so far as a judicial analysis is concerned, and is not as comprehensive as others already published; (*b*) after about ten pages of tabulated data a new subject is at once begun with no discussion or consideration of the significance of the experimental results recorded. This *pot-pourri* style of composition is more or less reflected in the impression one receives of the author's tendency to think of several matters without analysis and correlation. On the other hand, all the experimental procedure is very carefully described and the reader can analyze the results. In spite of the fact that the respiration tubes were "tarred" instead of tared, one is inclined to accept the results as reliable and the conclusions as sound.—RAYMOND H. POND.

Plant diseases.—The last annual report (21st) of the Agricultural Experiment Station of the University of Nebraska, issued January 29, 1908, contains the following papers of interest in reference to plant diseases.

POOL[7] discusses several diseases of tomatoes. Black rot, due to *Alternaria fasciculata* (C. & E.) Jones & Grout, occurs on the ripe fruit at the blossom end. The cavities within the diseased tissue are lined with the fluffy mycelium of the fungus. It was isolated and inoculations were made upon both ripe and green

[6] STOWARD, FREDERICK, On endospermic respiration in certain seeds. Annals of Botany **22**:415–448. 1908.

[7] POOL, V. W., Some tomato fruit rots during 1907.

fruit. Five days after inoculation the rotted area of the ripe fruit was 1.2^{cm} in diameter. No infection occurred in the green fruit. Culture characteristics are discussed. Rhizoctonia on the tomato is also discussed, the disease being marked by a chocolate-colored, wrinkled epidermis. The fungus penetrates the cells in all directions, and no conidia are formed. It was isolated and tomatoes were inoculated, resulting in their complete decay in two weeks, both ripe and green fruit. The ripe rot due to *Colletotrichum lycopersici* was studied. The fungus was isolated and inoculations were made, producing four days after infection a diseased area 0.6^{cm} in diameter on either ripe or green fruit. Fusarium of undetermined species and also *F. Solani* Mart. were isolated, used in inoculations, and the culture characters determined.

Miss WALKER[8] discusses and describes a form of Sphaeropsis differing from the ordinary form principally in the size of the spore, the size and thickness of pycnidium, and the absence of the ostiole. The new form seems to be more vigorous as a rot-producer that the old one. Inoculated into apples in every case it produced the characteristic black rot. The author suggests that possibly the variation in size of the spore may be due to the nature of the fruit upon which it is growing.

HEALD[9] briefly describes the various types of barley smuts, with notes on experiments as to the best mode of treatment for their prevention. The following treatments were used: formalin steep, modified formalin steep, hot water treatment, corrosive sublimate steep, copper sulfate steep. The percentage of germination was lessened by all the treatments except the hot water, being reduced 40 per cent. by formalin 1/10, and 70 per cent. by 1/15. The author recommends as the formalin steep one pint to 20–25 gallons of water.

WOLF[10] found *Pestalozzia uvicola* on ripe grapes. It was isolated in pure culture and inoculations made upon the grape, resulting in numerous pustules after proper incubation period. Sections of these pustules showed the characteristic spore, but, contrary to the usual mode of Pestalozzia, the spores were borne in what the author regards as well-defined pycnidia, which structure would be entirely out of accord with the genus or with any of the Melanconiaceae. It is unfortunate that the drawing (p. 71) leads one to infer that the spores are not borne in the true pycnidium, as the author describes, but rather in the cavity resulting from hypertrophy of the surrounding host tissues.—F. L. STEVENS.

Mold of maple syrup.—This mold, frequently observed during the past few years, has been ascertained by HEALD and POOL[11] to be *Torula saccharina* and was grown in pure culture on media of varying composition. They conclude that the concentration of the sugar solution in which the fungus was growing

[8] WALKER, LEVA BELL, A new form of Sphaeropsis on apples.

[9] HEALD, F. D., Seed treatment for the smuts of winter barley.

[10] WOLF, F. A., A rot of grapes due to *Pestalozzia uvicola* Spegaz.

[11] HEALD, F. D., AND POOL, V. W., The mold of maple syrup. 21st Ann. Rep. Univ. Neb. Agric. Exp. Sta. 54. 1908.

had little effect on the size of the spores or hyphae; and that ammonium nitrate can be used to a limited extent as a source of nitrogen, but that it is rather poorer than ammonium tartrate.—F. L. STEVENS.

The vegetative activity of chromatin.—DERSCHAU'S[12] results and theoretical views on the vegetative activity of chromatin are interesting. Many granular chromatin substances thrown out of the nucleus into the cytoplasm increase in size, assume spherical forms, and then, becoming oriented at the poles of spindle figure, function as centrosomes. This is regarded as the vegetative activity of the chromatin. His studies cover several forms of higher vascular plants, such as *Fritillaria imperialis*, *Iris germanica*, *Vicia Faba*, *Lilium Martagon*, *Funkia sieboldiana*, and *Osmunda regalis*. From his investigation of the pollen mother cell and meristematic tissue of these forms, he concludes that there exist central bodies in the mitotic figure of the fern and flowering plants which are of nuclear origin and are analogous to blepharophlasts.

The following is a brief summary of his account. In very young mother cells of Lilium, Funkia, and Osmunda, chromatin is observed escaping from the nucleus in various spots. Outside the nucleus the chromatin substances increase in size and assume spherical forms. The spherical chromatin substances refract light and close examination of them seems to show a reticulated structure. With stains they react like chromatin and linin. While the chromatin is escaping the nucleolus remains within, which shows that the substances thrown out are not nucleolar. In late prophase the spherical chromatin or "Sphaere" seems loosened and differentiated into two structures, one the center and the other a single heavy beaded fiber. Some of these centers make their way toward the *Hautschicht* during a later phase of mitosis and furnish the anchoring-place for the spindle; some lie scattered in the cytoplasm; and still others remain near the nuclear periphery. To each of these centers there is attached a single heavy beaded fiber, from which there seem to be spun out fine spindle fibers. Generally the spindle figures start as multipolar polyarch, then become bipolar, but remain in the polyarch condition until telophase; and therefore several centers persist without fusion at each pole, each spindle cone being associated with a single center. In rare cases some of these centers fuse together to form a kinoplasmic plate, which is connected by beaded heavy fibers with other centers that remain separate. In telophase the central and mantle spindles again take on a beaded structure. The centers and fibers, instead of entering into the constitution of the organizing daughter nucleus, remain in the cytoplasm and undergo certain changes in the structure. These centers at the pole of the spindle, DERSCHAU thinks, control the mechanism of mitosis. He states further that the centers may be structures allied to the blepharophlast, and are to be regarded as analogous with it, if not homologous; both lie near the nucleus, increase in volume, and mark the starting-point of fibers—one of cilia and the other of spindle fibers.—SHIGÉO YAMANOUCHI.

[12] DERSCHAU, M. v., Beiträge zur pflanzlichen Mitose, Centren, Blepharophlasten. Jahrb. Wiss. Bot. **46**: 103–118. *pl. 6.* 1908.

Cytology of Ascomycetes.—Miss FRASER and Miss WELSFORD have recently added another contribution[13] to their important series on the cytology of the Ascomycetes. The present investigation deals with two additional Discomycetes—*Otidea aurantia* and *Peziza vesiculosa*. The authors have studied principally the triple reducing divisions in the ascus, and their observations accord in the main with those of HARPER on Phyllactinia. They find in these two species, however, intermediate conditions between the early pairing of the chromosomes in Phyllactinia and their complete independence during the stages preceding reduction in Humaria, as described in an earlier paper by Dr. FRASER. In Otidea, for example, the chromosomes do not pair till the prophases of the third (or brachymeiotic) division; whereas in *Peziza vesiculosa* they unite during the prophases of the second division in the ascus. This variation in the time of chromosome union, as described for these species, is compared in tabular form with the conditions which obtain in Humaria, Galactinia, and Phyllactinia.

The authors describe two phases of the reduction processes—the meiotic phase, embracing the first and second divisions in the ascus, distinguished in Otidea by four chromosomes and in *Peziza vesiculosa* by eight chromosomes; and brachymeiosis, involving the second reduction, when the two sets of post-meiotic chromosomes become separated during the third division, thus resulting in two chromosomes in Otidea, and four in Peziza. A definite synaptic contraction occurs in connection with meiosis, similar to that first described by HARPER in Phyllactinia; but, unlike the case in Phyllactinia and in Humaria, a second contraction takes place in the two forms studied at the beginning of brachymeiosis. The authors regard the presence of both meiosis and brachymeiosis as evidence of the occurrence of two fusions in the life-history of these forms; although in neither form were the first, "presumably pseudapagamous," fusions found. Further confirmation of HARPER'S account of spore-formation is presented in that the authors find the spores delimited by the astral radiations. But they incline to the view that the rays represent, not active contractile fibers, but rather the paths of activity of an enzyme which is generated at the centrosome and which flows out equally all around the center, delimiting the spore by the chemical changes thus produced.—E. W. OLIVE.

Mitosis in Funkia.—An account of nuclear division in Funkia is given by Miss SYKES in two short papers,[14] one dealing with the reduction division in the pollen mother cell, and the other with the somatic division as it occurs in the archesporial cells and in the ovary wall.

The results may be summarized as follows: (1) The nuclear reticulum in

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[13] FRASER, H. C. I. AND WELSFORD, E. J., Further contributions to the cytology of the Ascomycetes. Annals of Botany **22**:465–477. *pls. 26, 27.* 1908.

[14] SYKES, M. G., Nuclear division in Funkia. Archiv für Zellforschung **1**:380–398. *pls. 8, 9. fig. 1.* 1908.

———, Note on the number of the somatic chromosomes. *Idem* **1**:525–527. *pl. 16.* 1908.

the resting stages of the mother cell is composed of a number of knots connected by filaments. The pairing of the reticulum appears at a very early stage. The number of pairs of knots, though it is impossible to make an accurate count, far exceeds the number of pairs of chromosomes. She concludes that in Funkia it is inadvisable to call the knots prochromosomes. (2) Occasional contact between the pairs of knots is observed in synapsis, but they do not constitute clear cases of fusion. (3) The double thread is formed from the reticulum during synapsis due to the paired arrangement of the constituents of the nucleus. (4) The double thread fuses into a single spirem, but at the time of segmentation into chromosomes it splits along the line of fusion (thus an element of each bivalent chromosome is not one-half resulting from the division of a single spirem, but an entire piece of the double thread which fused to form a single spirem). (5) Heterotypic division of chromosomes takes place along this fission, so that there is a true reduction division. (6) In each of the daughter chromosomes a new second split occurs longitudinally. (7) The reticulum and knots in the nucleus of the pollen grain are unpaired throughout, but a double structure is found in the prophase of the somatic nucleus. (8) The number of chromosomes in the somatic nucleus of *Funkia ovata* and *F. sieboldiana* seems to vary from 36 to 48, probably is 48, the reduced number being near 24.—S. YAMANOUCHI.

Fossil Osmundaceae.—KIDSTON and GWYNNE-VAUGHAN have recently published a second contribution[15] on the extinct Osmundaceae, which deals anatomically with two species of a new genus (*Zalesskya*) from the Permian of the Ural. *Z. gracilis* and *Z. diploxylon* are characterized by a central cylinder, which the authors infer to be protostelic from the manner of exit of the leaf traces. Unfortunately in one species the center of the fibrovascular tissues of the stem has disappeared through maceration, correlated with fossilization, and in the other by the crumbling away of the stony matrix. The authors admit that the general anatomy of the fossils is not distinctively osmundaceous. They place great diagnostic importance in this connection, however, on the minute structure of the xylem tracheids, which are characterized by multiseriate pits and vessel-like perforations of the pit membranes of the terminal walls. The authors seem to attach a somewhat exaggerated importance to these features, however, since both have long been known to occur in ferns not related to the Osmundaceae. They infer that their fossils make it "clear *that the central ground tissue of the recent Osmundaceae must be regarded as phylogenetically derived by modification from the central xylem of a solid* (sic) *protostele and that primitively it had no relation with the cortex whatever.*" This statement appears to have scarcely a better basis in logic or fact than their contention in the first article that foliar gaps are primitively absent in the Osmundaceae. Even if it be admitted that the authors' species are osmundaceous, which is very far from being certain, the conclusion reached appears hardly in accordance with sound reasoning. The

[15] KIDSTON, R., AND GWYNNE-VAUGHAN, D. T., On the fossil Osmundaceae. II. Trans. Roy. Soc. Edinburgh **46**[2]:213–232. *pls. 1–4.* 1908.

fact that a protostelic genus Lygodium occurs among the living Schizaeaceae, throws no light on the morphological nature of the pith in the central cylinder of the other schizaeaceous genera Schizaea, Aneimia, and Mohria.—E. C. JEFFREY.

Mitosis in Cynomorium.—BACCARINI[16] has published an account of vegetative mitosis in *Cynomorium coccineum* (Balanophoraceae). From a study of the nucleus in meristem of the roots and in parenchyma of the stem, he finds the following stages: (1) *Prophase:* (*a*) chromatin granules are uniformly distributed throughout the fundamental mass of the nucleus, with or without still larger chromatin knots or joints, the chromocenters; (*b*) the chromatic granules, separating from the faintly staining fundamental mass of the nucleus, aggregate gradually into a distinct number of larger masses, the chromocenters; (*c*) these chromocenters unite to form larger masses, more compact and lengthened, which constitute the prochromosomes; (*d*) some prochromosomes fuse together by their ends into a chain, which finally results in filaments of the spirem; the spirem by this time is homogeneous in structure, but it is uncertain whether it is a single continuous thread; (*e*) the filaments of the spirem segment into a definite number of chromosomes, which seem to be more numerous than the prochromosomes. (2) *Metaphase:* The chromosomes become arranged in the equatorial plate, where they divide and the daughter chromosomes separate. (3) *Anaphase:* The chromosomes accumulate in a convergent bundle at the pole. (4) *Telophase:* The chromosomes dissolve and form the fundamental nuclear mass with its chromatin granules.—SHIGÉO YAMANOUCHI.

Riella.—In the twelfth of the *Archegoniatienstudien*, which he announces to be the last, so far at least as concerns the liverworts, GOEBEL describes the brood buds of *Riella helicophylla*, *R. cossoniana*, and *R. Battandieri*.[17] These organs were first found by UNDERWOOD and HOWE in *R. americana*, and have not yet been observed in *R. Clausonis*. They consist of an unequally two-lobed disk attached by a single stalk cell somewhat excentrically placed on the upper surface. GOEBEL holds these gemmae to be "modified slime papillae," as in Marchantia, an effort at homologizing which seems to us strained. The smaller lobe is loaded with food and therefore heavier; so the gemma sinks in the water with this end down and from it rhizoids arise. The larger lobe, which he calls the germ disk, grows, and especially the meristematic tissue between the two, parting them by a rather long stalk. From the germ disk two plants are produced directly when well nourished, and otherwise one indirectly, that is, only after proliferation of the germ disk. GOEBEL also discusses the systematic position of the genus, concluding on rather doubtful grounds, it seems, that it should

[16] BACCARINI, P., Sulle cinesi vegétative del *Cynomorium coccineum* L. Nuovo Giorn. Bot. Ital. **15**:189–203. *pl. 7.* 1 08.

[17] GOEBEL, K., Archegoniatenstudien. XII. Ueber die Brutknospenbildung und über die systematische Stellung von Riella. Flora **98**:308–323. *figs. 11.* 1908.

form a fourth family of the order Marchantiales: Ricciaceae, Corsiniaceae, Riellaceae, Marchantiaceae, rather than be placed as an aberrant family in the Jungermanniales anacrogynae.—C. R. B.

Cleistogamy.—The examination of a large number of cleistogamous flowers of monocotyls and dicotyls showed HELENE RITZEROW[18] that all are reductions from the chasmogamous forms, and that the reductions follow a definite direction determined by the normal development of the chasmogamous form. The mode of reduction in the various floral parts is described in detail. The pollen grains of many forms germinate within the anther, the pollen tubes emerging in various ways. Chasmogamous flowers are generally so situated upon the plant that they receive better nourishment than the cleistomagous. So many forms are described that the work will be good for reference.

TUZSON[19] has observed for six years two trees of *Robinia Pseudo-Acacia*, 30 to 40 years old, and has found them producing only cleistogamous flowers. Adventitious shoots, six years old, from these trees also produce only cleistogamous flowers. The author believes that in this case the cleistogamy is entirely independent of external conditions and due rather to inner causes.—CHARLES J. CHAMBERLAIN.

Fossil polar plants.—NATHORST,[20] in connection with the publication of the results of the Russian Polar Expedition of 1900–1903, has given an account of the Triassic and Jurassic plants from the Island of Kotelny. Schizoneura is the only Triassic plant. Among the most interesting Jurassic remains are the leaves and cone scales of a pinelike conifer. As the affinity of these is not absolutely certain in the absence of structural evidence, they are denominated Pityophyllum and Pityolepis respectively. The scales present a remarkable appearance, for broadening from the base they narrow abruptly to an isthmus about the middle, to expand again at their upper ends. The question naturally suggests itself, whether the upper region does not correspond to the apophysis of modern pines. The reviewer has found somewhat similar cone scales in the Lower Cretaceous. The author takes occasion to criticize the erroneous reference of probable pine needles to the problematical Jurassic genus Cyclopitys (Sciadopitys). The latter he does not consider to form properly an element of the flora of the Mesozoic as it occurs in the northern hemisphere.—E. C. JEFFREY.

Phylogeny of Archegoniatae and Characeae.—SCHENCK[21] regards the bryophytes, pteridophytes, and Characeae as unrelated groups, the first two having

[18] RITZEROW, HELENE, Ueber Bau und Befruchtung kleistogamer Blüthen. Flora **98**:163–212. *figs. 36.* 1907.

[19] TUZSON, JOHANN, Ueber einen neuen Fall der Kleistogamie. Bot. Jahrb. Systematik, Pflanzengeschichte, und Pflanzengeographie **40**:1–14. *pls. 1, 2.* 1907.

[20] NATHORST, A. G., Mém. Acad. Imp. Sci. St. Petersbourg VIII. **21**: no. 2. 1907.

[21] SCHENCK, HEINRICH, Ueber die Phylogenie der Archegoniaten und Characeen. Engler's Bot. Jarhb. **42**:1–37. 1908.

come from the brown algae, and even the Characeae showing more resemblance to the brown algae than to other green algae. The origin of antheridia and archegonia from a plurilocular sporangium is developed along the lines already presented by DAVIS and HOLFERTY. To some of us, it would seem better to derive antheridia and archegonia from plurilocular sporangia of some hypothetical green alga than to refer them directly to the plurilocular sporangia of brown algae. The spore mother cells of archegoniates are compared with the unilocular sporangia of the brown algae, and the sporophyte of archegoniates with the thallus of brown algae. SCHENCK does not believe the sporophyte of pteridophytes can be derived from that of bryophytes. Even the complicated antheridium of the Characeae is referred to the plurilocular sporangium of the brown algae.—CHARLES J. CHAMBERLAIN.

Translocation in green tissues.—RYWOSCH points out[22] that translocation must depend upon the concentration gradient from the peripheral cells to the vascular bundle. This gradient is due in part to the excess of food made in the cells best illuminated, and also to the fact that transpiration cooperates doubly, by reducing the amount of water and by determining the movement of water. Thus those cells next the bundle are first to receive the water supply and those nearer the periphery are driest. He shows that the emptying of leaf tissues is not simultaneous, peripheral ones being emptied first, and that the whole process is greatly retarded when transpiration is checked. [Yet it must not be forgotten that there are plants in which transpiration cannot be invoked as an aid to translocation, since it is practically non-existent for weeks or months at a stretch.] The concentration is also kept low in the inner cells by the making of starch in them. RYWOSCH also adds a note on the function of the starch sheath, holding that its character as a reserve is very doubtful.—C. R. B.

Hygroscopic living leaves.—HANNIG[23] reports what he says is the first recorded instance of the movement of living leaves produced by variations in the water-content of the cell walls. The leaves of various hardy species of Rhododendron rise and fall, roll and unroll, according as they are subject to freezing and thawing weather respectively, though the same movements may be produced by other conditions which reduce or increase the water-content of the cell walls. Turgor is not concerned, HANNIG says, because dead or live, narcotized or unnarcotized, leaves exhibit movements equal in extent and kind. HANNIG's argument is not convincing, and it seems unlikely that this conclusion is sound. In fact, too little is known of the physics of water and cell contents under the conditions described to make it possible to state accurately the precise relations involved.—C. R. B.

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[22] RYWOSCH, S., Sur Stoffwanderung im Chlorophyllgewebe. Bot. Zeit. **66**[1]: 121–130. *figs. 2.* 1908.

[23] HANNIG, E., Ueber hygroskopische Bewegungen lebender Blätter bei Eintritt von Frost und Tauwetter. Ber. Deutsch. Bot. Gessells. **26a**: 151–166. 1908.

Development of Ulva.—The development and conjugation of gametes and also the germination of the zygote are described by SCHILLER[24] for both living and fixed materials. Three kinds of gametes are found in Ulva and also in Enteromorpha: (1) *megagametes* or giant gametes, which do not conjugate and are incapable of development; (2) *parthenogametes*, of medium size, which germinate into normal plants without any conjugation; and (3) *microgametes*, which are smaller than the parthenogametes and which produce new plants only after conjugation. The relation between the nucleus and the protoplasmic mass in the various gametes is believed to be the reason for the differences in behavior.—CHARLES J. CHAMBERLAIN.

Paleobotanical technique.—The veteran and distinguished Swedish paleobotanist NATHORST has contributed remarkably to the technique as well as to the facts of that science. His most recent contribution to technique is in connection with the use of collodion impressions of the surface of fossil plants for microscopic study.[25] With the article are published photomicrographs made from such films, illustrating the structure of fossil fern sporangia, the epidermis of the leaves of ferns, and gymnosperms and angiosperms in a fossil condition. Even a Cupressinoxylon yields results with this method.—E. C. JEFFREY.

A Paleocene flora.—M. PIERRE MARTY of the Royal Belgian Museum of Natural History has published a memoir[26] on the Paleocene flora of Trieu de Leval. Perhaps the most interesting feature of this publication is the discussion of the phylogeny of the important genus Quercus, à propos of the new species *Dryophyllum levalense*. The latter has chestnut-like leaves and the author concludes that among the living oaks it has its nearest affinities in those ancestral forms persisting in India, Japan, and the East Indies. The flora as a whole, with the above exception, presents a marked resemblance to that at present existing in northern South America.—E. C. JEFFREY.

Algae and Fungi of Iowa.—BUCHANAN[27] has brought together in convenient form, with keys, a list of the algae reported from Iowa, based upon the study of numerous recent collections. The list includes 180 species, and the bibliography of "Iowa Algae" includes nine titles.

The same thing has been done for the Erysiphaceae of Iowa by ANDERSON,[28] including of course a complete list of hosts. The recognized species and varieties number 28, involving 35 synonymns; while the hosts reported number 187.—J. M. C.

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[24] SCHILLER, DR. JOSEF, Beiträge zur Kenntniss der Entwickelung der Gattung Ulva. Sitzungsb. r. Kaiserl. Acad. Wiss. Wien **116**:1–26. *pls. 1, 2.* 1907.

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Spermatogenesis in mosses.—The VAN LEEUWEN-REIJNVAANS add a few details to their former paper and announce their abandonment of this field of research,[29] after a brief excursion into it with rather startling results.[30] Now they report centrosomes in the antheridial cells of *Fegatella conica* (contrary to BOLLETER) and in *Pellia epiphylla* (contrary to IKENO). In Mnium (sp.?) they find (as in Polytrichum) in the last division from 8 to 4 chromosomes, 2 long and 2 short, which is a transverse (not diagonal) reduction.—C. R. B.

Acorus Calamus.—This species was introduced into Europe in the middle of the sixteenth century, and it has always been known that the European plant produces no seeds. A study of the development of the pollen and embryo sac by MÜCKE[31] shows that both are so defective that the production of seeds is impossible. The reason for the sterility is supposed to be unfavorable climatic conditions.—CHARLES J. CHAMBERLAIN.

Germination of zoospores.—Continuing his studies upon the spores of algae, SAUVAGEAU[32] describes the germination of the zoospores of Cladostephus, Algaozonia, and Cutleria. Methods of making cultures of zoospores are also discussed.—CHARLES J. CHAMBERLAIN.

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[30] Cf. BOT. GAZETTE **45**:358. 1908; **46**:234. 1908.

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